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This handbook provides the elementary school teacher with specific suggestions regarding use of materials and organization of effective learning experiences in science at this level. The book contains three sections: An introduction emphasizes both science knowledge and process while the other two sections deal with subject matter topics for grades 3 and 4. Suggestions for evaluation follow each science topic. A bibliography of both children's books and professional books for science teaching in the elementary school is provided. An extensive film list is also developed. Topics developed in grade 3 include electricity, the earth and the sun, needs of plants and animals, sound, weather, friction, gravity, motion, and rocks. Topics developed in grade 4 include using a compass, the moon, plants, sound, weather, moving things, and water.

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SCIENCE

Grades 3-4



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SCIENCE

Grades 3-4

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FOREWORD

The school science program for New York City children begins with pre-kindergarten science, as outlined in the publication, *Pre-Kindergarten Curriculum* (Curriculum Bulletin, 1965-66 Series, Number 11). The program continues with *Science: K-2*, (Curriculum Bulletin, 1965-66 Series, Number 7), which presents a teaching guide for each of the grades K, 1, and 2.

Science: 3-4 provides the teacher with specific materials and suggestions for organizing effective learning experiences in the science area at this level. Both science knowledge and science processes are stressed. Among the new features which merit special attention are the evaluative activities which follow each of the major topics.

In behalf of the school system, I wish to express my appreciation to the Bureau of Curriculum Development, the Office of Science Education, superintendents and directors; the elementary science coordinators, and the hundreds of teachers and supervisors who have made this publication possible by their tryouts in the classroom, by their designing of materials, and by their care in the preparation of this handbook.

Bernard E. Donovan
Superintendent of Schools

ACKNOWLEDGEMENTS

This handbook was developed under the direction of Joseph O. Loretan, Deputy Superintendent of Curriculum, as a joint venture of the Office of Elementary Schools, Truda T. Weil, Assistant Superintendent; the Bureau of Curriculum Development, William H. Bristow, Assistant Superintendent; and the Office of Science Education, Samuel Schenberg, Director.

The preparation of this handbook was a cooperative enterprise which enlisted the efforts of hundreds of teachers and supervisors in the Elementary Science Revision Project. The general coordinating group for the Revision Project consisted of William H. Bristow, Samuel Schenberg, Harry Milgrom, and Julius Schwartz.

Harry Milgrom, Assistant Director, Office of Science Education, supervised the Revision Committee and reviewed and contributed to the materials developed for this handbook.

Julius Schwartz, Consultant in Science of the Bureau of Curriculum Research, was the principal researcher and writer for *Science: Grades 3-4*, and chairman of the Revision Committee.

Muriel Green, Science Consultant, Bureau of Curriculum Research, was the assistant chairman of the Revision Committee and researcher and writer of science curriculum materials for this handbook.

The following district science coordinators, members of the Revision Committee, participated in the writing, testing and evaluation

of the handbook materials for *Grades 3-4*: George Barr, Rose Blau-stein, Arthur DeSantis, Mary Graeber, Esther Marcus, Anna M. Rosenblum, Joan Rosner, Abraham L. Sperber, Thomas G. Vinci, Ada Werner, and Bernard Wertheim. Herbert Karp, Assistant Principal, P.S. 197, Queens, also served on the Committee.

Acknowledgement is due also to the many teachers, supervisors, science coordinators, curriculum assistants, and specialists from institutions outside the Board of Education who assisted in the preparation of the seven handbooks in the original series, *Science: K-6*, which has served as the basis for the current revision program.

Victor Spevack, Bureau of Audio-Visual Instruction, assisted the Revision Committee in preparing the list of films and filmstrips. Lucia Engels, Bureau of Libraries, assisted in the preparation of the bibliography. Thanks are extended to Edward G. Bernard, Director of the Bureau of Audio-Visual Instruction, and to Helen R. Sattley, Director of the Bureau of Libraries, for their cooperation. Richard R. Kinney, Supervisor of School Gardens, prepared the draft of *The School Garden in the Science Program*.

Anna Maltz, in charge of stereographic and typing services at the Bureau of Curriculum Research, gave expert assistance in the setup and preparation of the typed material at various stages of its production.

Jan Margo made the illustrations and designed the layout for this handbook. Maurice Basseches, Editor, had overall responsibility for design and production.

DEVELOPMENT OF THE SCIENCE PROGRAM FOR THE ELEMENTARY SCHOOLS OF N. Y. C.

The science program for the elementary schools stems from a series of projects that have been under way for almost two decades to give the study of science full status in the elementary curriculum in New York City.

One project, originating in two districts, resulted in the preparation of *Science in Everyday Living* (Curriculum Bulletin No. 6, 1947-48 Series). This publication, reporting early childhood activities and experiences in the classroom, was distributed to all elementary schools in New York City.

Material developed in other districts for the intermediate grades was published as *Source Materials in Elementary Science* (Curriculum Bulletin No. 3, 1949-1950 Series). This publication, outlining science materials, experiences, and units, was also made available to all schools.

To meet the need for broader consideration of the overall K-12 science program, exploratory studies and conferences were conducted in 1950, culminating in the appointment and work of a science advisory panel which established a set of goals and principles later accepted as a working program by the Curriculum Council.

Another step was taken in 1950 when the Curriculum Council of the Board of Education designated a Science Advisory Committee to coordinate the development of a 12-year science program for the New York City Schools. This committee consisted of: *William H. Bristow, Director, Bureau of Curriculum Research, Chairman; Alfred D. Beck, Science Supervisor, Junior High Schools; Francis X. Carlin, Science Supervisor, Vocational High Schools; Harry Milgrom, Science Supervisor, Elementary Schools; Samuel Schenberg, Science Supervisor, High Schools; Jacob H. Shack, Assistant Superintendent, Division of Curriculum Development, Secretary.

*The positions indicated are those which were held in 1950.

Concurrently, committees of teachers and supervisors were set up to prepare courses of study in science for the elementary, junior high school, and senior high school levels.

The work of the elementary school committee was directed first by the late Isaac Bildersee, Assistant Superintendent, and then by Herman Schneider, former Science Supervisor, Elementary Schools.

During 1953, a committee under the chairmanship of Harry Milgrom and including Ruth Berken, Allen Burnham, Frances Harmon and Martha Shapp prepared a *Course of Study in Science for the Elementary Schools, Grades K-6*, which was adopted by the Board of Superintendents and the Board of Education in July, 1954. This gave the elementary schools the first approved framework on which to build a science program, and completed the process of organizing a science sequence from the kindergarten to the twelfth grade.

A program of curriculum development and implementation was approved by the Board of Superintendents at its meeting on January 4, 1955 and became known as the Elementary Science Project. This project was a joint undertaking of the Bureau of Curriculum Research and the Office of Elementary Science.

Thirty-one pilot schools in seventeen districts participated in the development of materials. To facilitate organization of production, committees were designated to develop materials in each of the seven areas of the program: Magnetism and Electricity, The Earth in Space, Living Things, Sound and Light in Communication, Weather, Motion and Force in Transportation, and Earth and Its Resources. Each committee consisted of teachers and supervisors from pilot schools, district science chairmen, curriculum assistants, science coordinators, and in some cases, representatives of cooperating institutions in New York City.

The work of the seven committees was under the direction of Harry Milgrom, Supervisor of Science for the Elementary School Division, and coordinated by Julius Schwartz, Consultant-in-Science of the Bureau of Curriculum Research.

The reports of the committees were prepared for publication by an editorial committee consisting of Allen Burnham and George Barr, Office of Elementary Science, and Julius Schwartz, Chairman. Jan Margo, a teacher in the All-Day Neighborhood School program at P.S. 108 M., served as a consultant and illustrator for the handbooks.

Between the years 1958 and 1962 the seven handbooks, *Science: Grades K-6*, (Curriculum Bulletin 1958-59 Series, Numbers a-g) each dealing with a separate area of science from Kindergarten to Grade 6, were distributed to

all of the elementary school teachers of New York City. During this period, an intensive program of teacher training was instituted to implement the use of the handbooks in the schools. Under the leadership of Harry Milgrom, the staff of science coordinators assigned to the twenty-five district superintendents conducted workshops, demonstration lessons, in-service courses, and faculty and grade conferences to familiarize the teaching staff with the new program.

In-school television programs for children, based on the handbooks, were cooperatively developed by WNYE, the Bureau of Curriculum Research, and the Office of Science Education. These programs served both for direct pupil instruction and for teacher training.

After-school television programs for the training of elementary school teachers were initiated by Samuel Schenberg, Director of Science, and supervised by Harry Milgrom, Assistant Director, with the active cooperation of WNYE, the Bureau of Curriculum Research, and the Division of Elementary Schools. Teachers' guides for these purposes were prepared and distributed. These television courses for teachers were held at the end of the school day and were received in school centers throughout the city. Each telecast was followed by an intensive workshop, using the materials presented on the program. In a later period the same course was presented to teachers who wished to view it at home, and a special guide was prepared for that purpose by Muriel Green, Science Consultant.

The emerging elementary science program was accompanied by an expansion of science fairs, clubs, assembly programs, and trips. More and more, science became part of the daily experience of all elementary school children.

In 1963, the Bureau of Curriculum Research and the Office of Science Education launched the present revision program. One reason for the revision is to bring together science content formerly presented in seven handbooks, so that a teacher may find all of the instructional materials for her grade in a single publication. In addition the revision reflects recent advances in science, and in the methods of teaching science. While retaining intact the basic scope and sequence of the original series, the experiences are enriched, and the number and variety of activities are increased. More suggestions are given to the teachers to stimulate the teaching of science as inquiry, through approaches which place children in the role of innovators, explorers, and discoverers. The teacher is given more assistance in planning, in using equipment, and in meeting the needs of children with varying abilities and interests. New introductory materials are incorporated to highlight modern developments, trends, and emphases in modern education. Integral to the revision are a series of items to assist the teacher and the children in evaluating the effectiveness of the teaching and the learning.

A panel of principals served as advisors to the Revision Project. The panel included Paul J. Fitzgerald, 164 K; Thea S. Klein, 59M; Irving Kreitzberg, 41 M; Sidney Levy, 92 X; Maude E. McGrath, 29 R; Hermine J. Nelson, 99 K; Pearl Newman, 16 K; Emil Soskind, 188K; Dirck Stamler, 75M; and Mary E. Vogt, 134 Q.

A Revision Committee, staffed with district science coordinators, worked on the new handbooks during the period 1963-1966, including the summers of 1964 and 1965. A Kindergarten Team, consisting of Muriel Green, Alice Harwood and Julius Schwartz, had the special responsibility of planning, researching and writing the original kindergarten topics. These topics were then tried out in eighteen pilot schools. This project is described fully in *Science: Grades K-2*, which was published in the spring of 1966.

Because of the urgency of the fast developing *Operation Headstart*, the Kindergarten Team was assigned to write a science program for the pre-kindergarten curriculum. This science material appears in the *Pre-Kindergarten Curriculum Guide*, which includes all the curriculum areas, and should now be considered a part of a Pre-Kindergarten—Grade 12 science program of New York City.

Present plans call for the publication of the revised materials of *Science 5-6* in 1967.

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Introduction

MEETING THE NEEDS OF ALL CHILDREN

Science meets the needs of all children since it offers them endless opportunities to explore, to manipulate, and to discover, as they try to find the what, how, and why of the world around them. The science program is designed to provide a variety of experiences in the form of trips, experiments, constructions, and projects which will appeal to children of varying backgrounds, interests, and capacities.

The Grade 4 topic, *Our Nearest Neighbor: The Moon*, for example, begins with children's wonder at the night sky. The moon hangs over New York City for all our children. As they watch the moon each night for a period of time, they note its changing appearance and make sketches to help them remember. The careful moon watchers discover that the moon appears in a different part of the sky each night. In the classroom, children try to find out why the moon appears to change shape, by experimenting with a model moon and a source of light. On radio, television, and in their readings, children follow the continuing story of moon thrusts and moon landings, and they locate current lunar events on such places as the *Sea of Tranquility* or the crater called *Copernicus*. They find these large features by revisiting the moon in the nighttime sky, perhaps with the help of binoculars. They begin to understand that the moon has a geography of its own. As children plan their own trips to the moon, they use concepts of distance, size, time, and motion.

Science lessons come in many "sizes" and "shapes". Characteristically, children may be experimenting, constructing, discussing, reading, observing, making drawings, making measurements, making exhibits, taking care of plants and animals. Science lessons may take the form of a planned trip in or around the school building, to the school garden, in the neighborhood, or to a nearby park. A science lesson may be the spontaneous reporting by children of what the windstorm did the previous night. A science experience may last two minutes, five minutes, an hour or more. It may be part of an interrelated series of experiences and activities, or it may stand uniquely by itself.

There are many roads to science learning and there are many settings for science teaching. The developmental class lesson, led by the teacher, is only one of the shapes that a lesson may take. On different occasions, children may work in small groups or by themselves. Since children learn at different rates and in different ways, there must be many opportunities for individual work. Children need time to think, time to work things out for themselves, without pressure from their classmates or teacher. Not all children will necessarily be working in science at the same time.

Using This Handbook to Meet the Needs of All Children

In the *Approaches and Concepts for the Child*, you will find, for each topic, the significant concepts which all children should learn. Following these are suggested problems. For example: in Grade 4, Topic A, *Sounds Are Carried By Air and other Materials*, is developed through such problems as the following:

1. Can sound travel through a tube?
2. How can we detect quiet sounds?
3. Why do people use a megaphone?
4. Why did people in early times "keep an ear" to the ground?
5. Can sound travel through a string?
6. How could you signal a friend who is underwater?
7. How can we make a string telephone?
8. How can you see the sound of your voice?
9. Why do we see lightning before we hear thunder?
10. Do sea shells have the sound of the sea in them?
11. What makes the sound in hollow objects?
12. What makes echoes?

For each topic the teacher *will use those problems that best serve the needs and interests of her group*. The problems should also be selected so as to develop adequately the basic concepts stated in the introduction to the topic. The teacher should feel free to extend the investigation of the topic along lines suggested by the children.

Following each problem in the Handbook is a list of understandings which the children may be expected to gain. It is important that the understandings

be formulated by the children on the basis of their experiences and *be expressed in their own words*. It is not intended that all children or all classes will arrive at all of these understandings, or be limited solely to these.

In summary: when we approach science as an exploration, we invite each child to make his own contribution to this unique enterprise, and to share in the learnings of all.

SCIENCE AS PROCESS AND AS KNOWLEDGE

"Science means various things to different people. Many accept it as an organized body of content to be studied from a science textbook. Some think of it as a new kind of magic. Others consider it to be an absolute authority.

"An increasing number believe it is something to be feared. Comparatively few recognize science for what it is — an enterprise created, designed, and managed by human beings. . . . We must make every effort to help our young people understand science in this light. To do this we must keep in mind the two basic components of science.

"One component has to do with science as a way of investigating the world of nature. . . . But science is more than a way of finding out. It is what the scientist finds out, not only the method. It is the tested knowledge of our environment that has come from using the methods. . . . At the pinnacle of this knowledge, however, are the grand ideas that have been forged in the creative, informed minds of scientists. . . . Both process and product are inextricably involved in the scientific enterprise. Both represent human activity. . . .

"As teachers we properly refer to the process part of science teaching as problem solving. In order to teach science as problem solving, we must get children involved in the process. They must be encouraged to ask questions; but more important we must help them develop the ability to ask thoughtful questions. Children must be encouraged also to speculate about answers to their questions. . . .

"We cannot give children the science ideas which they are supposed to understand. Each child "catches," or comes to understand, an idea on his own. Our job is to set the stage for this to happen and guide the process once it is under way."*

*From "What is Science" by J. Darrell Barnard. *Elementary School Science Bulletin* No. 63. National Science Teachers Association, Washington, D.C. September, 1961.

The material in this handbook is designed to combine the two components of science, *process and knowledge*. For example, the observation and measurement by children of the changes in length and direction of a given shadow at different times (process) leads them to the generalization that the sun changes its position in the sky during the day (knowledge).

The understandings listed at the end of each problem in this handbook, and the broader concepts found in the introduction to each topic, represent *knowledge* that should flow from the children's investigations. Interwoven in the development of each problem and implicit in the question which triggers each problem is the *process*.

Following are some of the processes in science investigations. The listing given here is not intended to suggest the order in which the investigation is to proceed. Nor is it essential that all of these be included in any one investigation. *And we should keep in mind that while children are discovering, they should be finding out something which, for one reason or another, they want and need to know.*

1. *Asking Questions.* This handbook is designed to encourage the asking of questions. The posing of a question is an invitation to children to engage in a scientific enterprise. Of course the most significant questions are those which children ask. See *The Role of Questions* on page 7, for further discussion of this topic.

2. *Experimenting.* An experiment is a way of finding out; it is not an end in itself. In an experiment the materials are carefully selected and the conditions are carefully arranged. This is different from an *experience* in which the materials and events are observed in the natural world. An experiment is a technique through which man tries to discover nature's secrets.

One aspect of the experiment is the *control*. When children are asked how they can be *sure* that a certain condition produces a given effect, they are led to see the need for a control. For example, if a child hypothesizes that hanging a wet cloth outdoors in full sunlight will make it dry faster, he should also hang a similar wet cloth outdoors in the shade. The one in the shade serves as the control. It makes possible an accurate comparison leading to a reasonable conclusion.

Children should be encouraged to devise their own experiments. It will be helpful for the teacher to ask frequently, "How can we find out . . . ?" Indeed, the children's involvement in planning an experiment is just as important as the doing of the experiment. They should plan (if possible) to test a single factor at a time. For example, if they wish to find out whether green plants need light, they will place some plants in the light and some in the

dark, and water them equally. If they do not water both sets of plants, they will not know whether the difference between the plants is the result of lack of water, or lack of light. A *number* of plants will be grown in the light and in the dark to answer the criticism that the plant in the dark may have been "a sick plant to begin with".

3. Predicting. Children should be encouraged to predict results, to propose explanations and then to test them. Predicting results will help children focus their thinking on a problem. Checking results will help them evaluate their thinking. The process of predicting also adds excitement and a sense of "playing a game" to the learning of science. In the third grade, children are asked to predict what will happen to a plant if its leaves are removed; if half of its leaves are removed; if only one or two leaves are removed. Children perform experiments to check their hypotheses.

4. Observing. This involves making use of the senses to gather information. Children use their muscles and other parts of their bodies to make observations as they push, pull, put things together, and take things apart. The teacher encourages them to use all their senses when they investigate, and to report what their senses indicate. Sometimes they extend what they learn from their senses by using an instrument. A hand lens, for example, helps them see a tiny insect in greater detail.

5. Interpreting. This involves comparing sizes (longer, shorter, larger, smaller), comparing textures (smooth, rough), and weight (light, heavy) of common objects. It includes distinguishing and naming temperature differences as being warmer or colder; identifying sounds made by familiar objects or events; identifying odors of familiar substances. It involves noticing *changes* in color, size, odor, state (such as from solid to liquid), shape, and position.

Children should be helped to distinguish between an observation and an interpretation. For example, a jar of water is exposed for a number of weeks and the level of the water is marked each Monday. Children may *observe* that the level is 3" deep at the outset, 2½" a week later, and 2" two weeks later. An *interpretation* of the data is that the water level in the container drops over a period of weeks.

6. Measuring. Observation may include measurement. Rough measurements come first, and then instruments are used to refine these measurements. A child puts his finger into a glass of water. He feels (observation) that the water is warm. He then places a thermometer in the water to see how warm it is (measurement). Sometimes children make their own measuring instruments: paper strips are cut to indicate the height of a growing plant over a period of time, and these made into a graph which represents the growth.

There are stages in the development of measurement skills. A child grows a number of plants from seed. He first compares the height of two plants and sees that one is taller than the other. He then asks himself, "How much taller?" and measures to find the answer.

7. Keeping Records. Records are kept in many ways: in written words, maps, photographs, tape recordings, numbers, drawings, graphs, and in collections of objects (for example, dry seeds from various plants displayed in transparent containers). When children gather data and look at it, they begin to understand that many examples make generalizations more valid.

For example, in Grade 4, children experiment by changing the position of the fulcrum (balancing point) when they use a ruler to raise a book. They use a rubber band to pull one end of the ruler down, and record the length of the stretched rubber band on a chart.

Gathering data, of course, is not enough. It has little value unless the data is examined and interpreted. In the example just given, the data furnishes a basis for generalizing about the relationship between the position of the fulcrum and the force needed to move the book.

8. Classifying. This involves collecting and organizing things. It may mean separating things to find likenesses or differences. It involves comparing things and grouping them. Children should be guided to an awareness of the reasons for classifying things: to simplify, to discover underlying or basic similarities and differences. Children should be encouraged to classify things for their own reasons, and to use their own basis for classification. They may wish, for example, to organize their rock collection on the basis of size (small or large), or on the basis of surface (smooth or rough), or on the basis of color (light or dark). Each of the methods may have significance to children.

As they pursue the study of rocks, they find it necessary to use a combination of such characteristics as hardness, color, texture and brittleness to identify a particular rock and distinguish it from others. These, indeed, are the characteristics employed by scientists in identifying rocks.

9. Generalizing. At the end of each problem in the Handbook there are *some* of the understandings or generalizations that children may suggest. These are based on their observations, experiences, and experiments. Throughout the work in science, children should be encouraged to generalize in their own words. This will make the process of forming generalizations one which involves careful, critical thinking.

THE ROLE OF QUESTIONS IN TEACHING SCIENCE

Good questions are the keys to good teaching in all curriculum areas. In science, questions have a special role since they are the starting point for children's investigations. In spirit, this is essentially the way in which scientists initiate research. Questions give purpose and direction to activity. Therefore the science program outlined in this handbook is developed through problems that are posed as questions.

Children ask questions naturally. An important goal in science teaching is to encourage and cultivate this questioning attitude. Children should feel that school is the place to ask questions, that their questions are important, and that questions often trigger exciting explorations. The teacher helps set the stage by arranging for situations which provoke questions. By the kinds of questions he asks, the teacher also serves as a model for the children as they develop and improve their skill in questioning.

Answers are found in a variety of ways. Occasionally the teacher, a book, or other children may provide answers. However, answers become more meaningful when children find them in the course of their *own* investigations.

Questions serve many purposes. Some useful question starters are:

- "What would happen if . . .?"
- "How can we find out . . .?"
- "How could you be sure that . . .?"
- "How can we (do) . . .?"
- "How many ways can we (do) . . .?"
- "Where could we find . . .?"
- "What happened . . .?"

And let us not forget to ask children, "What questions do you have?" and to counter children's questions frequently by asking, "What do you think?"

Children should come to understand that there are many questions for which there are still no answers. We are uncertain about the cause of the earth's magnetism. We do not know whether life exists on Mars, although, before the next edition of this handbook appears, we may have the answers. As children go on with their science studies they will understand that *all* answers in science are man-made, hence subject to error and subject to change. There is no final and absolute authority in science. This does not, however, deny the importance of the principles and theories which scientists construct to explain phenomena. But most significant principles and theories in science lead to the discovery of new principles and theories.

The significance for the teacher of this approach to science "answers" is that children's ideas and proposals should be considered, and that the teacher need not become *the* authority or a spokesman for *the* authority. Rather, science in the classroom should be an adventure in which children and the teacher participate. Children should come to regard science as an endless quest rather than a finite body of information.

Following are some typical questions related to the work in *Science: 3-4*, grouped to indicate their special character.

Questions which draw on children's home experiences

What care are animals given in our homes and in a pet shop?

What seeds could you find in your home right now?

Questions which lead to trips and surveys

What happens to rainwater when it strikes the ground?

What seeds travel by hitch-hiking?

How do winds get their names?

On what kinds of surfaces do things slide best?

Where is rock used around the school?

Questions which lead to close observation

What do you feel when you hold your finger against your throat as you are talking?

Does that bird keep on flapping its wings all the time as it flies?

Where is the sun now?

What happens to the line in the thermometer when you breathe on the bulb?

Which of these rocks have layers?

Questions which provoke experimentation

Does water sink into bare soil as fast as it does into grassy soil?

What happens to our potted plants when they are subjected to extreme cold?

What happens when we change the position of the fulcrum?

Questions which help children group and classify

On what kinds of surfaces do things slide best?

What kinds of things make high tones? What kinds make low tones?

Which of the rocks around our school occur naturally? Which are man-made?

Which of these seeds travel by land? Which by air? Which by water?

Questions which lead to measurement and collecting of data

How does temperature change from fall to winter?

What is the temperature of some of the things in our room?

Do plants grow better in sand or in soil?

Does a sandy soil absorb water faster than soil with less sand?

How much easier is it to pull a load up a ramp with a gradual slope than to pull it up a steep slope?

Questions which challenge children to propose ways of finding out

How can we find out if all plants need sunlight to live?

How can we find out if there is air in water?

How can you find out which substances carry electricity and which do not?

How can you find out which way the moon seems to move in one night?

How can we tell without using an instrument how fast the wind is blowing?

Questions which ask children to predict

What will happen to the level of snow in a glass when we take it indoors?

What will happen to the sound if we shorten the milk straw horn?

If we sandpaper a rough piece of wood, will we be able to make something slide over it more easily?

What will happen to this plant if we turn it so its leaves face away from the window?

If you add a third gear to a "gear train," how will it turn?

Questions which challenge children to propose explanations

Why are similar plants found in places which are far apart?

Why are wheels better than rollers for moving a vehicle?

What makes the moon shine?

Why does a baseball batter pick up dust and rub his hands with it before he goes to bat?

Why do we see lightning before we hear thunder?

THE ROLE OF THE EXPERIMENT

The classic way through which man tries to discover nature's secrets is by experimenting. When children experiment, they are intrigued by the elements of surprise and discovery that are a part of such investigations. They begin to develop patterns of thinking and working which are characteristic of scientists. In the context of science teaching, we differentiate *experience* from *experiment*. Experiences may include the child's observing goldfish in an aquarium, examining a rough surface with a magnifying glass, or taking a trip around the school to look for natural and man-made rocks. An experiment, on the other hand, is usually a cooperatively developed enterprise (teacher and children) with appropriate materials set up for the purpose of finding the answer to a particular problem.

The significance of the experiment is that it helps to find something out rather than to prove something. *Its character is more "Let's find out whether . . ." than "Let's prove that. . ."* The teacher sets the stage by providing situations which stimulate children to raise problems. In a real experiment, there should be some doubt about the outcome in the investigator's mind. The experimenter may consider a certain outcome to be most probable but he is uncertain of it.

Although an experiment is conducted to solve a problem, every research scientist has had the experience of finding new problems during his experimentation. Pupils, also in their experiments, will open up many new lines of thinking; as they attack one problem, additional problems will be disclosed. Where feasible, therefore, the program of experimentation may be extended to include some of these new problems.

Finally, it should be noted that experiments are appropriate for any grade in the elementary school. Third grade children may experiment to find out what happens to a plant when fertilizer is added to the soil. In the fourth grade, children set up experiments to determine how fast rainwater sinks into different kinds of soil.

Guidelines for Experimentation

1. The Setting

The setting is provided by situations which may develop from asking the "trigger" questions in the science handbook, from children's individual experiences, from class trips, from provocative materials, from previous experiments. All of these may result in problems or questions. For example, in the fourth grade, after children discover from their observations that the sun's rays hit Earth at more of a slant in winter than fall, they experiment to see what effect the slant of the sun's rays has on the amount of heat received.

2. *Getting Into Action*

The children should be given an opportunity to design the experiment and to decide on and gather the appropriate materials. Depending on the availability of the materials, physical conditions, and safety considerations, the experiment should be performed by pupils individually, by groups working together, or by one group in the class. It is important that children have opportunities to manipulate the materials and to work at their own pace. Before proceeding with the experiment, the children should understand how the experiment is related to the problem to be solved.

3. *Making It Scientific*

Wherever possible, use a *control*. This is simply a method of providing a basis for accurate comparison. When children try to find out whether plants grow better in sand or in soil, they grow a *number* of plants of the *same size and type* in both of these media. They observe the plants for a number of weeks and compare the two groups for size and general development.

Test only *one* variable at a time. For example, when children experiment to learn what a plant needs so as to live, they should deprive the plant of *either* sunlight or water, not both. In this way, they can arrive at a conclusion that has validity.

Take advantage of the fact that you have a number of children who may perform the same experiment. It may be found that variations in the results that children get are due to differences in the *techniques* used, variations in *observational skills*, differences in ability to *report* their observations, or differences in the *materials* being used (the use of a weak dry cell as compared to the use of a fresh dry cell).

Results of experiments should be recorded, reported, and summed up, to help the children gain the most understanding from the experiments. The greater the number of experiments and observations, the greater the possibility of arriving at a basic explanation or generalization.

4. *When the Experiment Does Not "Work"*

In a sense, every experiment "works," that is, what happens is a result of natural influences. For example, children try to find out how to make a piece of wood slide more easily over another piece of wood. They lubricate one surface with vaseline. If they find that it is harder rather than easier to pull the piece of wood, *this is not a failure; it is an opportunity*. For here is a *real* problem—not one predetermined by the teacher. Asking the children how to solve this *real* problem leads to the highest level of experimentation because children are actually cast in the role of scientists. They may suggest using more or less vaseline, lighter blocks of wood, surfaces other than wood, or a lighter oil. All of the suggestions should be accepted and tested, as far

as possible. Since during a school year, many of the investigations suggested in the handbook will lead to situations in which something appears not to "work," it is essential that the teacher capitalize on these opportunities for involving children in science learning.

MATERIALS FOR ELEMENTARY SCIENCE

For effective learning of science, children must have as many first-hand experiences with real materials as possible. To assist you in planning this, the handbook includes lists of materials that are necessary for each unit in Grades 3 and 4. In general, the lists are based on the assumption that children will work in groups of four, although there will be many occasions when the teacher may depart from this arrangement. The *E-1 Science Supply List* or the *G-1 General Supply List* contain the items which may be ordered at requisition time (usually in the fall).

Sources

In addition to the standard type of science materials provided by the school, such as magnets, magnifying glasses, and thermometers, the teacher has many other sources to draw from. These include materials that are found in the classroom such as the window pole, paper, paper clips, drinking straws, and empty milk cartons.

Much of the equipment normally found in the kindergarten, such as blocks, paints, and toys, are useful for science teaching in grades 3 and 4. Children can contribute science materials such as empty spools, leaves, pebbles, plastic containers, and shoe boxes. The local hardware, variety, and pet stores are sources of science materials. Neighborhoods with gardens, parks, beaches, ponds, and streams are excellent sources of science materials. Other sources of science materials are museums, the ASPCA, botanical gardens, zoos.

Since we continually emphasize conservation, children should be made aware of the need to discriminate when collecting science material outdoors. Whereas removing a fallen leaf from beneath a tree does no harm, leaves ripped from branches may injure the tree. In general, plant species that are scarce, such as many of the wild flowers, and specimens that are on private property are not to be collected. Small wild creatures, taken briefly to the classroom, should be housed and fed properly and eventually returned to the environment from which they had been removed. Children in early grades should be accompanied by an adult on any field trip.

Storage

It has been found that no one method of storage will be convenient for everyone. Shoeboxes or other containers may hold many materials for a

particular unit such as the one on electricity. This may be part of the permanent equipment for your room. Expensive equipment should be stored centrally and be available, on order, to the classroom teacher. Schools may order cabinets containing tote trays for the storage of science equipment. Each school will select a method that best meets its needs.

Safety

The bulletin *For Greater Safety In Science Teaching* is in all schools and should be consulted. The following rules apply particularly to the teaching of science in the elementary schools.

1. Materials must be safe for children to use. For example, plastic containers should be used when possible, instead of glass containers.
2. Pupils are to be under the direct supervision of a teacher at all times.
3. Devices or equipment brought in by a child should be pretested before using them with the children.
4. Discuss safety cautions in handling materials for which there might be a special hazard, even if the teacher is demonstrating them. Discuss the science principles involved in safety. For example, water and sand should be available whenever we are working with fire.
5. Wherever possible, the safety application of science principles should be taught. In the study of wheels and ball bearings, for example, a basis is developed for understanding the potential dangers of leaving round things on floors and stairs.
6. House current (110 volts) is NOT to be used. Only dry cells (1½ volts) are to be used for experiments with electricity.
7. Children are NOT to carry laboratory equipment or apparatus through the halls when classes are moving about.
8. Children are NOT to taste chemicals or other materials. The only exceptions are foods purchased and handled under sanitary conditions.

SCIENCE AND THE READING PROGRAM

Children are fascinated by explorations in science, and this interest may be utilized in many ways to improve reading ability. The teacher can guide children in the use of newspapers, magazines, and books to find information, to satisfy curiosity, and to enjoy the sheer excitement of adventuring in science. In the early school years, youngsters become familiar with the elements of their environment which they can see, hear, feel, smell, taste, and touch. They add to their speaking and reading vocabularies the names of these elements and the words which describe impressions made by them: hot, cold, wet, dry; loud, soft; high, low; rough, smooth. From year to year, as new experiences

introduce new science words, their speaking, reading, and writing abilities grow rapidly. For example, when planning a garden, children consult planting instructions to find out how to sow and care for their plants. They become familiar with the names of many common seeds, vegetables, flowers, and gardening tools. Educationally disadvantaged children, and those to whom English is a second language, increase their English vocabulary as they learn words describing concrete objects and their use in science experiences.

Making Experience Charts, Oral and Written Reports, Graphs

Pupils are encouraged to describe in their own words what they want to investigate through their experiments, what they propose to do and to use, what they observe, and what they learn. The teacher may print an experience chart as the children dictate the story of each experiment. Once a child grasps the significance of such a statement it will not take long before he can read the words of which the statement is composed. Gradually, he will gain the ability to write and read his own reports, thus further strengthening both science and reading skills.

Step by step, as children pursue their simple investigations, they are taught to prepare, read, and interpret charts, tables, and graphs which show the results of such measurements as length (of shadows), weight, time, temperature, speed (of wind), force, and direction.

Preparing Exhibits

In the preparation of hall and classroom displays, children practice the skills required in writing and reading titles, captions, labels, and descriptive text. Much of this work may require that pupils read and follow specific directions. Through all of these science activities, reading is needed and used.

Implementing Reading in Science

Children should be given an opportunity to select reading material. The teacher should make available a variety of suitable books and other references in anticipation of a topic that may be studied, or as a source of information after a question has arisen. In this way, children begin to develop the habit of using many sources; they begin to appreciate the role of references in research. Printed matter in elementary science mostly falls into the following groups: textbooks, trade books, reference books, magazines and free materials.

Since New York City has its own well-defined curriculum in science, no single textbook provides the readings essential in our program. Texts are used as references, for supplementary reading, for useful illustrations or

techniques. For this purpose children should have available the texts of different publishers and of different grade levels.

Trade books, with their great diversity of subject matter, reading levels, styles, and formats, are excellent aids to the teacher in meeting the needs of individual children. On pages 322-338, grouped according to science areas, is an annotated *Bibliography* for children of grades 3 and 4.

Reference books such as encyclopedias should be available, if possible, in the classroom and in the school library. Children need help, of course, in using these references properly.

Many manufacturers print material that may contribute to science learnings in elementary schools. Their public relations departments are cooperative in sending supplementary material to the schools. The usefulness of each publication must be carefully assayed before making it available to the children.

AUDIO-VISUAL MATERIALS IN THE SCIENCE PROGRAM

A large variety of audio-visual materials is available in our schools; this permits the teacher to utilize a multi-sensory approach in the development of science concepts. These materials also motivate learning and make it more pleasurable. Thus stimulated, the pupils become more curious and begin to investigate, read, explore, and experiment.

Some aids such as the chalkboard, the felt board, and the bulletin board appeal to sight. The chalkboard, particularly, is available to every teacher and has great potentialities. To illuminate an idea, a large clear sketch, in colored chalk if appropriate, is a fine teaching aid. The value of the chalkboard is enhanced if the teacher develops the drawing with the help of the children. The drawing grows as ideas grow, as children contribute to its lines and labels. The chalkboard makes it possible for all children in a group to center their attention on the same drawing while they discuss a problem. The pupils should be encouraged to use the chalkboard to explain and clarify their own ideas.

Motion pictures, filmstrips, and transparencies are used in various kinds of projectors found in the schools. Magazines and newspapers are good sources for pictures that may be hung in the classroom and viewed in greater detail by using the opaque projector. Charts and models that children make are often more meaningful than commercial ones.

Other aids appeal to hearing. These include radio, tape recordings, phonograph records, sound films, and filmstrips. They offer the teacher additional opportunities for meaningful science lessons.

Television is a valuable teaching aid and can do much toward furthering the objectives of science teaching. The teacher should consult the TV guides provided by the Board of Education, and plan to use television as an *integral part* of her science program.

A teacher occasionally may use audio-visual materials to introduce a new unit or topic. Such use serves to stimulate the interest and curiosity of the children and helps them formulate the problems they will try to solve. Audio-visual materials may be used during the exploration of a unit or topic to supply information needed, to reinforce knowledge or skills, to stimulate research, and to encourage follow-up activities. These aids may also be helpful at the end of a unit to provide a review, or as part of a unit's culmination.

Audio-visual aids in science are primarily for instruction. Films and filmstrips are most effective when they can contribute specifically to the topic which is being studied. It is important that they be within the understanding of children of the grade and age level. It is not necessary that filmstrips be shown in their entirety; only those frames that are pertinent to the unit need be used. Projectors should be tested ahead of time, to make sure that they are in working order.

If the children are adequately prepared for the material to be presented, and are stimulated to be active participants, the learning is more effective. There should be ample opportunity for language training, oral and written. Children should be prepared for the new words anticipated by the teacher.

A follow-up program reinforces the knowledge and skills learned from the film, filmstrip, or other audio-visual material. This may take the form of creative writing, art work, trips to zoos and museums, making collections, reading in science books, and making reports.

A list of films and filmstrips appropriate for the science topics in Grades 3 and 4 will be found in pages 312-321 of this handbook.

USING NEIGHBORHOOD RESOURCES

New York City is a wonderful laboratory for the study of natural science. Within the five boroughs such places as an ocean front, a bay, a waterfall, a river, and a swamp may be explored. Almost any neighborhood has a hill, a valley, a vacant lot, rocks, soil, plants, and animals. The school building itself, with its natural and man-made stone, reveals how man uses some of

nature's resources. The schoolyard, exposed as it is to the sun, wind, and rain, is an exciting place for observing the forces of nature at work. The trees on the street announce the changing seasons. The street becomes a "rainshed area" and the gutter a "river bed" whenever it rains. Sparrows, gulls, squirrels, and insects are among the wild animals that may be observed. A host of others abounds in nearby parks and beaches. The surface of the City reveals its past; its rivers, lakes, rocks, and stones bear evidence of the glaciers which advanced over it until some 25,000 years ago. Placed as it is on the great Atlantic flyway, one of four main paths taken by migrating birds, New York City is a stopover for many of them.

In keeping with the principle that science for children should be rooted in first-hand experiences in the real world, neighborhood trips form an essential part of the science program. In this real world children see *real* buildings going up, *real* machines at work, *real* changes in the seasons *real* sun and clouds, *real* hills and valleys.

The following guidelines for trips are suggested:

1. There should be a good reason for making the trip, and children should know the reason.
2. There should be planning for safety, transportation, time schedule, collecting, note-taking, permissions.
3. The teacher should make a preliminary trip to determine the suitability of the place to be studied.
4. There should be group discussions about conduct and courtesy on the trip.
5. There may be some division of specific responsibilities for observing, collecting, and other simple duties.
6. Do not hurry children. A second trip to the same locale is often essential.
7. Follow-up after the trip may include discussion, displays, and reports.

Many trips are suggested in this handbook. The Curriculum Report, *Operation New York*, gives fuller descriptions of walks which may be taken to explore neighborhood resources, such as those which follow.

1. A walk to study natural and man-made rocks and their uses, in and around the school building and in the immediate neighborhood. For example, various kinds of colored stones, rocks of different textures and appearances, concrete, pebbles, and cut stones for driveways, colored-glass store fronts, plaster, and even porcelain (baked clay) sinks and tile in hallways.

2. A walk to discover hills in the neighborhood.

3. A trip to see the continuous natural process of building up and tearing down. This includes the erosion of soil which forms gullies and exposes the roots of trees, the rusting of iron, the expansion and cracking of sidewalks and stones, the decaying of leaves, and the breaking of dead twigs.

4. Visits to locations around the school where one can study seasonal changes of trees, shrubs, hedges, flowers, buds, weeds, seed pods, leaves, lawns, and vines.

5. Surveying the neighborhood to see at first hand the surprising varieties of animals found in a city, and the tenacity and abundance of such life. Included are birds, furry animals, insects, and fish.

5. Investigating buildings under construction, studying uses of various materials, tools, and vehicles.

7. A picnic in a park where children can learn about a lake, a swamp, waterfalls, flowers, and trees.

8. A visit to the harbor.

9. An outing to a sandy ocean beach for dozens of fascinating observations and discoveries.

10. Walks to find and explain sounds and odors in the neighborhood.

11. A walk to see machines at work in the neighborhood.

12. A walk to see different forms of transportation in the neighborhood.

13. A walk to see different forms of artificial light in the neighborhood.

THE SCHOOL GARDEN IN THE SCIENCE PROGRAM

The school garden is an outdoor classroom for science education. Here children can observe living plants in a natural environment of soil, sunlight, air, and water. It is a laboratory where children discover what plants need in order to grow, how plants change as they grow, how long it takes different plants to mature, how plants grow under different conditions, what happens when plants are too crowded, how plants change as the seasons change.

For city children especially, the school garden is a place for many surprises and delights. Foods such as beans and peas, which may have been seen coming only from a can or a frozen-food package, are now seen growing and ripening on living plants. A salad made in the classroom from radishes and lettuce freshly harvested by children from their own garden is a rare treat.

Carrots, turnips, Swiss chard, spinach, and peanuts are some of the other food plants which are easily grown in school gardens. There may be a harvest of the spring planting in June or of the summer planting in September. Not to be ignored are the exotic aromas and rich colors of garden flowers.

As children work with garden tools they learn about their proper use and care. They find out about the value of the hoe in breaking lumps of soil, of the rake for removing pebbles and stones and for smoothing the soil, of the sprinkling can (younger children) hose (older children) for watering it.

Areas other than science are enriched by gardening experiences. One of the most valuable experiences is that which leads to improved interpersonal relationships. Recognition and understanding of a fellow planter's needs and desires grow as a gardening project develops. The school garden is also a laboratory in language arts, providing as it does a common basis for interchange of ideas, for discussion and writing of plans, and for recording the observations that follow. Some mathematics is used in planning and laying out the rows, and in measuring the growth of plants.

The school garden is a place where children observe the forces of nature at work. A downpour of rain makes gullies and washes away some of the precious topsoil; a drought dries the soil and makes it dusty, and causes the plants to wilt and droop. Children note that plants in the sunny part of the garden grow differently from those in the part which has less sunlight.

The school garden is a great teacher. Here children learn the dependence of man on plant and animal life and on the relation of this life to air, sun, soil, and water. And when children see that what *they* do makes a difference, they have learned one of the prime concepts of conservation.

EVALUATION

Evaluation is an integral part of the learning process. It starts when teaching starts, and goes on long after a lesson or unit is completed. "Success" is revealed to the teacher by many signs. It may be simply the gleams in children's eyes or the smiles on their faces. In early childhood, it may be the painting and blockbuilding that children engage in following a science experience. It may be children's capacity to put a science principle to work in a new situation. It may be the number and kinds of questions that children ask. It may be their answers to such questions as, "What are we trying to find out?" or, "What did we learn?" It may be their skill in manipulating materials, their involvement in long-range projects. It may be what children do after they leave the school building: the hobbies they pursue, the games they play, books they read, radio and television programs they observe.

Science is both knowledge and process. It consists of *knowledge* in the form of facts and principles; it consists of the *processes* employed by scientists: hypothesizing, experimenting and generalizing. Science teaching is concerned with both of these characteristics. We are concerned, for example, with a child's knowing *that* outdoor shadows change in a certain way during the day and with his knowing *how to find out* that they change. It follows that our evaluation of science teaching must take both of these facets into account. Since it is difficult to conduct tests for the *processes* of science, it is necessary for the teacher to employ other methods of evaluation, as indicated in the foregoing paragraph.

At the end of each topic in Grades 3 and 4, there is a section entitled *Evaluative Activities*. Teachers may use these questions and activities as models, selecting appropriate ones, and adapting others. The answers which are provided are typical and suggestive; the teacher should expect and accept other words and other ideas as well. The illustrations suggest how questions and answers may be adapted for children with language difficulties.

It should be emphasized again that evaluation takes place all the time, not merely at the completion of a topic. *Evaluation serves as a sensitive instrument to guide the process of learning, moment by moment.* This Handbook is designed to foster evaluation as a built-in characteristic of teaching and of learning.

The following are some significant objectives and goals that the science curriculum is designed to promote.

Objectives

Can children:

1. set up experiments
2. state the problem
3. suggest ways to solve a problem
4. manipulate materials
5. record data
6. interpret data
7. generalize from the results of an experiment
8. state new concepts
9. apply these concepts?

Goals

Are children:

1. increasing their interest in science
2. increasing their awareness of their environment
3. reading science periodicals and books
4. engaging in science activities on their own
5. developing keener observation
6. seeking answers to their own questions
7. distinguishing fact from fancy
8. beginning to expect order and predictability in relation to natural phenomena?

For the purposes of evaluation, *objectives*, as used in the preceding, may be defined as the short-term and limited aims of a single topic or portion of the curriculum. *Goals* are here defined as the long-term and broad-scope aims of the entire science curriculum.

PLANNING FOR YOUR YEAR IN SCIENCE

Many teachers have asked for suggestions in planning their year in science. There can be no *one* way of scheduling that will apply to all teachers and children, since the placement, depth, and duration of any science topic depends on many variables: on pupil interest, maturity, experiential background, language difficulties, on unexpected and unusual happenings. Thus a new building excavation in the neighborhood will certainly influence the scheduling of the Grade 3 study of rocks and soil.

There are, however, certain constants which the teacher can depend on in planning science: the logical sequence of science concepts, the sequence of themes which have been planned in other curriculum areas, the changing seasons, holidays and other special days.

The sample schedules shown here reflect some of the constant factors which enter long-range planning. The teacher may use these as a guide, but should design her own so as to include the variable factors that enter into her own situation. Note that a topic may be taught in its entirety, without a break, or that it may be sub-divided into several sub-topics, to be taught at different times during the school year. It should also be noted that science may occur without formal scheduling. For example, in Grade 4, plants are studied, but not animals. There is no reason however, why a fourth grade class should not keep fish, chameleons, salamanders, insects, in their classroom aquarium or terrarium.

To summarize, the science schedule planned for the year should be structured to serve as a useful framework, but flexible enough to meet the special needs of children, and to make the most of the unexpected and the unusual.

SAMPLE SCIENCE SCHEDULES

[illegible]

GRADE IV	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June
Finding Direction With a Compass	X	X								
Our Nearest Neighbor in Space: The Moon		X	X							
Getting New Plants			X							
Sounds Travel; Sounds Can Be Recorded				X	X					
*Weather and Climate From Season to Season					X	X	X			
Moving Things More Easily								X		
The Water We Use									X	X
*Period selected will depend on seasonal change to be studied. See pages 228-229.										

***SEQUENCE OF SCIENCE TOPICS IN KINDERGARTEN,
GRADES 1, 2, 3 AND 4**

The following table indicates the specific topics which are developed in the Kindergarten,
Grades 1, 2, 3 and 4, in seven areas of science.

Area	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4
Magnetism and Electricity 	A Magnet Holds On 80		Magnets 196	Electricity in Everyday Life 27	With A Compass Finding Direction 157
Earth in Space 	Spaces and Places Light and Dark 28 71		Sunlight and Shadows 187	The Earth and the Sun 41	Our Nearest Neighbor in Space: The Moon 174
Living Things 	What's Alive? Discovering With Our Senses 32 38 Seeds and Fruits 54 Discovering With a Magnifying Glass 44	Animals and Plants in Our Neighborhood 135	Animals and Plants in the Classroom 171	The Needs of Plants and Animals 54	Getting New Plants 194

Sound and Light in Communication 	Sounds Around Us 63	Making Sounds 149	How Sounds Are Made 75	Sounds Travel; Sounds Can Be Recorded 206
Weather 		Weather From Day to Day 106	Observing and Measuring Weather Changes 91	Weather and Climate From Season to Season 225
Motion and Force in Transportation 	Uphill and Downhill Seesaws and Balances 48 95	Moving on Land and Water 156	Friction, Gravity, and Motion 115	Moving Things More Easily 225
Earth and Its Resources 	Heat Changes Foods 59 Getting Wet and Drying 75 Water Mixes with Foods 84 After it Falls 90 Blowing Soap Bubbles 100		Rocks and How We Use Them 134	The Water We Use 277

*Pages indicated for topics in Kindergarten, Grades 1 and 2 refer to *Science: Grades K-2*.



Grade Three



Electricity in Everyday Life

A. ELECTRICITY AROUND US

Background for the Teacher

Seldom has man been made more aware of his dependence on electricity than on the evening of November 9, 1965 when 30 million people, living in an area of 80,000 square miles, embracing parts of eight of our states and most of Canada's Ontario province, were plunged into silent blackness by a power failure. In New York City the blackout lasted for about thirteen hours. During this time 630 subway trains gasped to a halt with 800,000 passengers trapped in them. In hundreds of stalled elevators, office workers were suspended between earth and sky. Traffic lights failed and main arteries became snarled. Drivers ran out of gas only to discover that gasoline pumps could not work without electricity. Apartment buzzers summoned nobody and fire alarms were mute. Airports, post offices, computers, television sets, refrigerators—all stopped functioning. The entire Northeast seemed to have fallen victim to its elaborate grid of power networks that girdle the region. As never before, people were alerted to the role that electricity plays in their lives—in providing energy for the light, sound, heat, and motion in the countless devices of modern civilization.

Approaches and Learnings for the Child

Children are familiar with electrical devices such as lighting fixtures, television sets, vacuum cleaners, refrigerators, and electric bells. Although it is not intended that, at this time, they learn how electrical devices work, we can increase their awareness of the things electricity does for us in the school, home, and community. We can also help them acquire certain habits of safety in relation to electricity.

CAUTION: At no time do children experiment with devices that are plugged into the electric current outlets found in buildings.

From the activities suggested, children learn the following.

Electricity is used to do many jobs for us.

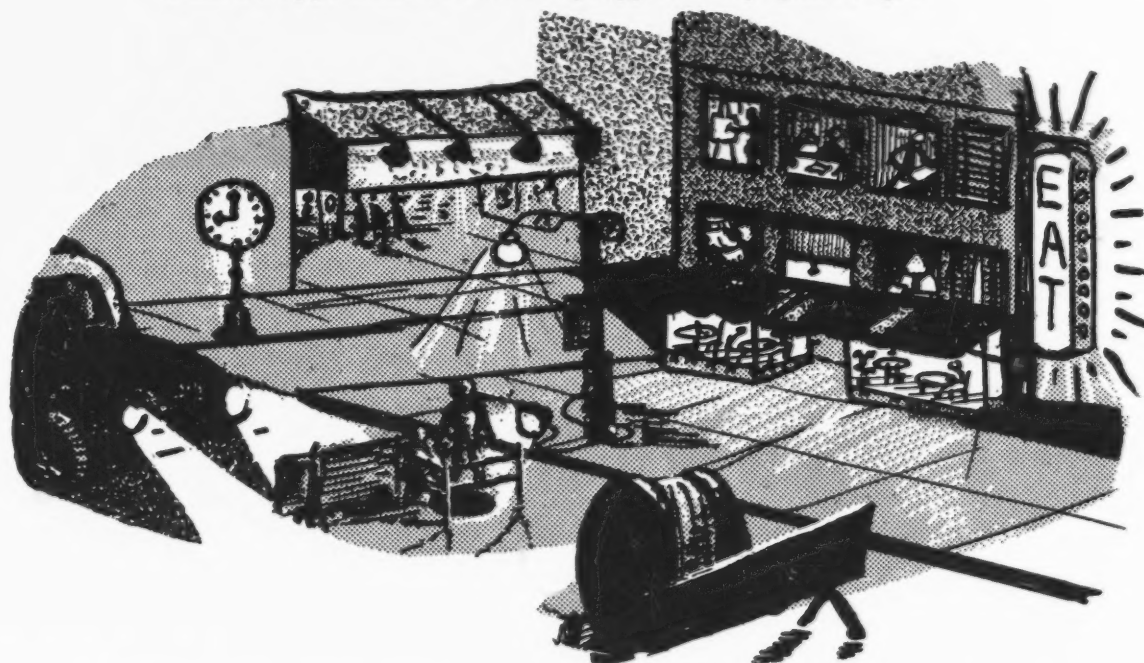
Electricity gives us light, heat, sound, and motion.

1. What things in our school are worked by electricity?

Children look around the classroom and take a trip through the building to discover electrical devices. Where possible, they observe the wires leading to the devices.

Ask the custodian to help. The following are some electrical devices that may be observed: overhead light fixtures, desk lamps, electric mimeograph machines, hot plates, various kinds of projection machines, tape recorders, intercoms, record players, radios, or other appliances with visible attachments to electric outlets.

- *Many things in our building are worked by electricity.**
- *Electricity goes through wires.*
- *Electricity gives us light.*
- *Electricity makes things move.*
- *Electricity makes bells ring.*
- *Electricity makes radios, television sets, moving picture projectors, and record players work.*
- *Electric appliances should be plugged in by grown-ups.*



2. What things on our street are worked by electricity?

Take the class on a trip outside the school to discover electrical devices such as street and traffic lights, electric signs, door bell switches, electric

* Statements set in italics and following bullets (•) are understandings which may result from the activities.

and telephone wires, electrical tools being used by workmen; lights, horns, and radios on automobiles.

- *Electricity is used to do many jobs for us in our neighborhood.*
- *Electricity helps light our streets at night.*
- *Electricity helps move traffic safely.*
- *Electricity helps carry telephone messages.*
- *Electric tools help men drill, dig, saw, and lift things.*

3. What things in your kitchen are worked by electricity?

Ask children to observe the electrical devices in their kitchens and tell about them in class the next day. The following are typical.

Electricity helps keep our food cold, cook it, chop, slice and mix it.

Electricity helps us light the room, run clocks, toast bread, iron clothes.

Have the children make scrapbooks to illustrate this theme.

- *We use electricity to do many jobs for us.*

4. What toys are worked by electricity?

Have children bring to school and display any battery-operated electrical toys they may have, such as electric telephones, trucks, cars, tractors, toys with lights, robots, or toy fans and vacuum cleaners. If possible, have them discover the source of electricity (dry cell) and its use.

- *In many toys the electricity comes from a dry cell.*
- *Electricity makes the toys light up, move, and make sounds.*

EVALUATIVE ACTIVITIES

1. From magazines and newspapers obtain pictures of busy street scenes, home interiors, factories, and other places utilizing electrical devices. Have the children point out and discuss the various uses of electricity.
Play this game. See which team is first to find five places where electricity makes things move, or produce sounds, or light up. Ask children to invent other games using the pictures.
2. Have a classroom science fair or electrical exhibition where the children bring in many small electrical devices. Each child acts as a demonstrator and "salesman" for a particular item. He discusses the uses, advantages, safety, price, and other special features. Each child stands behind a desk which serves as a demonstration booth. The children find out all they can about their own items. Signs and labels may be made. Invite other classes to visit.

B. ELECTRICITY TRAVELS IN A CIRCUIT

Background for the Teacher

To understand electricity, it is essential to know something about electrons. Electrons are particles found in the atoms of all substances. In a basic sense, therefore, all substances are electrical in nature. Thus it is not possible to "make" electricity; all that is needed is a "push" to start a *flow of electrons* in one direction. Current electricity, then, is a stream or a flow of electrons. This stream or current flows in a continuous path from a source of energy, through the device to be operated, back again to the source of energy and so on. This complete path is called a circuit.

When we say that electricity flows through a copper wire in a circuit, what really happens is that each atom of copper in that wire is passing some of *its* electrons on to neighboring atoms. The neighboring atoms do the same, and so on along the wire. An electric circuit may be compared to a circle of children, each with pieces of chalk in his hand. Each child represents an atom in the wire; the chalk represents electrons of that atom. When each child passes a piece of chalk to his neighbor a "current" is flowing. This analogy, however, is imperfect because the chalk is not really a natural part of each child in the sense that an electron is a part of each atom.

A "dry" cell, used as a source of electrical energy in the experiments in this topic, is not actually dry: some of its components are moist. When the cell is connected in a circuit, chemical action within the cell supplies the energy to give the "push" needed to start a flow of electrons around the circuit.

Electricity can move easily through certain solids such as metals. These materials are called *conductors*. Other materials, such as glass and rubber, prevent the movement or flow of electrons. Such materials are *insulators*.

If a means of breaking the circuit is provided, a current can be started or stopped at will. Thus, switches are used to close or open a circuit. A knife switch is one of the simple types of switches. When its blade is down, that is, when it is touching the fixed part of the switch, there is a continuous flow of electrons through the switch. When the blade is raised, the circuit is broken and the flow of electrons is stopped. An ordinary pushbutton is another kind of switch. It usually contains a coil or spring which opens the circuit when the button is released. A switch may be inserted in any part of a circuit because it does not matter where the circuit is broken.

Approaches and Learnings for the Child

The experiences listed here are based on the use of dry cells. Children must be warned that they are not to use house current. Each child should be given a number of opportunities to wire the various devices so that he can discover for himself how a complete circuit makes the device "work." Children should be encouraged to bring in objects operated by dry cells, such as quiz games and telegraph sets, in order to study as many simple circuits as possible. From the activities suggested, children learn the following.

Electricity travels in a circuit.

A dry cell is a source of electricity.

A switch is used to make or break an electric circuit.

Metals are good conductors of electricity.

Non-metals generally are poor conductors of electricity and may be used as insulators.

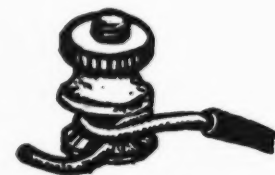
Insulators prevent electricity from going where it is not wanted.

1. How can a dry cell be connected to a bulb to make it light, or to a bell to make it ring?

Present the bulb or bell, dry cell, and wire and ask children to suggest how to hook them up. Follow their instructions, even making errors, and see what happens. Give all the children an opportunity to make an electric circuit using the dry cell, wire, and bell or bulb.

Point out that dry cells, bells, and bulbs each have two connections (posts or terminals), so that electricity can enter the device by one and leave by the other. Electricity travels in a *circuit* (a word which sounds like "circle").

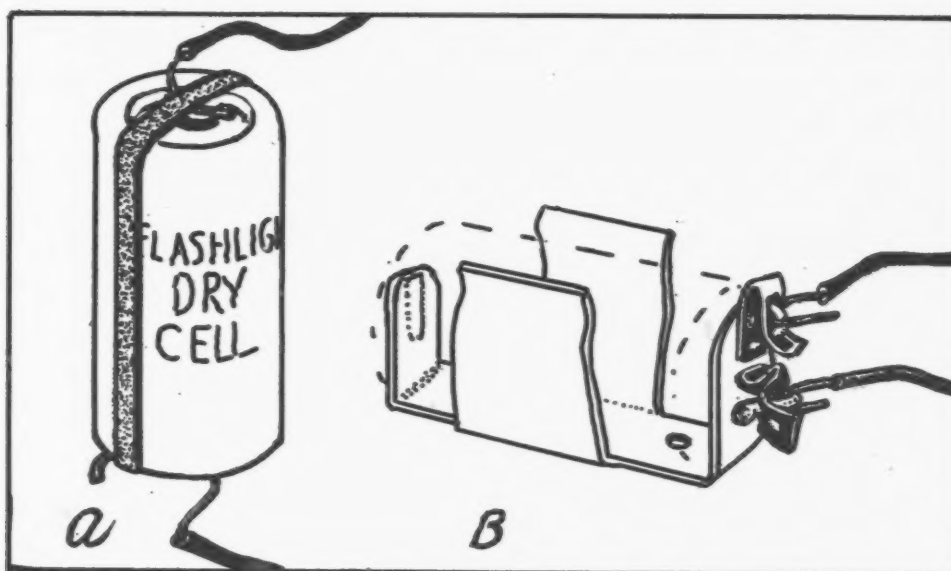
Note: Any type of insulated wire can be used, providing the insulation is removed where the wire is attached to the terminals. All wire connections should be tight if electricity is to flow steadily through them.



Wire attached to terminal.

The most suitable wire is bell wire, which is a solid wire with insulation of plastic, rubber or cotton.

The large #6 dry cell is rated at $1\frac{1}{2}$ volts. A small flashlight cell also can be used if arrangements are made for attaching wires to it. On the E-1 *Science Supply List* (Item number 14-2408) there is a dry cell holder which may be used very effectively. Ask children to suggest other ways of using flashlight cells conveniently.



Connecting wires to a flashlight cell
a) using a rubber band
b) using a dry cell holder.

To make connections quickly, for demonstration purposes or for practice, attach the wire to a test clip. Test clips can be ordered from the E-1 List, item number 14-2408.



Two kinds of test clips.

When not in use, the wires should be disconnected from the dry cell. Bare wires should never touch each other or the frame of the bell.

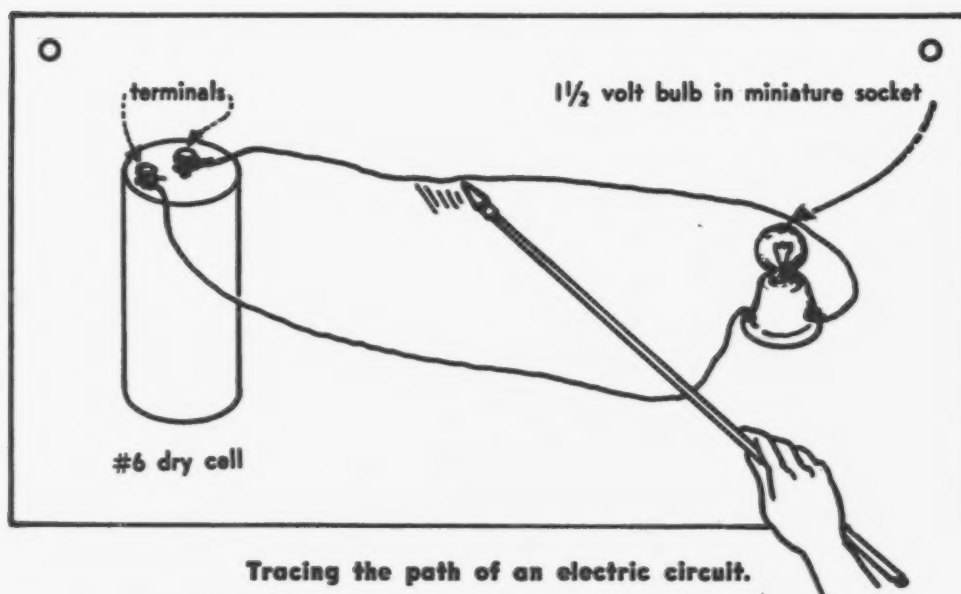
On the chalkboard or a chart, make a drawing of a *complete circuit*. This is also called a *closed circuit*. Have children use a pointer to trace the path of electricity from a dry cell terminal through a wire to one

GRADE THREE

connection of the bulb, through the bulb, and back through the wire to the other dry cell terminal.

Drill until the class becomes familiar with tracing circuits. Also use a drawing which shows a bell instead of the bulb.

In addition to drill work from drawings, have the children trace circuits using actual materials.



- *Electricity travels in a continuous path or circuit.*
- *Bells ring and bulbs light when electricity passes through them.*
- *The dry cell supplies electricity.*
- *The bell, bulb, and dry cell each have two connections to allow electricity to move through them.*

TIPS ON MAKING DRY CELLS LAST LONGER

It is worthwhile to allow children to experiment with different arrangements when wiring bells or bulbs to dry cells. Unless precautions are taken, however, this activity could deplete the school's stock of dry cells quickly.

The teacher can help preserve the cells by explaining to the children that at no time should a wire be connected directly across the terminals of a dry cell for more than an instant. When bells and bulbs are properly connected to dry cells, the current in the circuit is limited by the devices. But when a wire is placed directly across the terminals of the dry cell, a very large current flows through the wire. This is called a **SHORT CIRCUIT**.

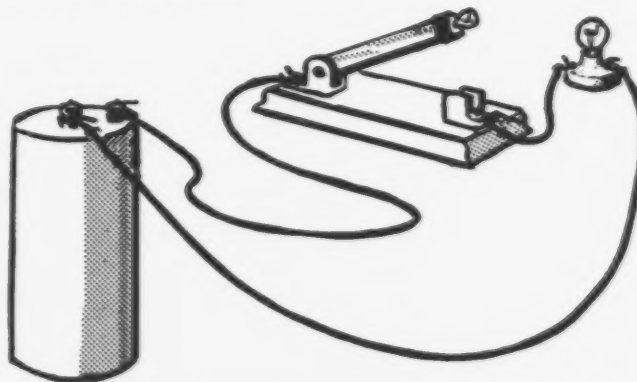
Since a dry cell has only a limited electrical capacity, a short circuit can drain it severely. In addition, the excessive current will make the wire causing the short very hot. The wire should be disconnected quickly and carefully. Frequently the rapid chemical action during the short eats holes in the zinc case of the cell through which the contents can leak out.

The two wires connected to the dry cell terminals may touch at some distance away in the circuit. This also results in a short circuit equivalent to the direct short.

Children should be taught to recognize and avoid these "shorts."

During the children's experimentation the teacher should move among them and call attention to possible short circuits. Good housekeeping also dictates that all dry cells should be disconnected at the end of the practice period.

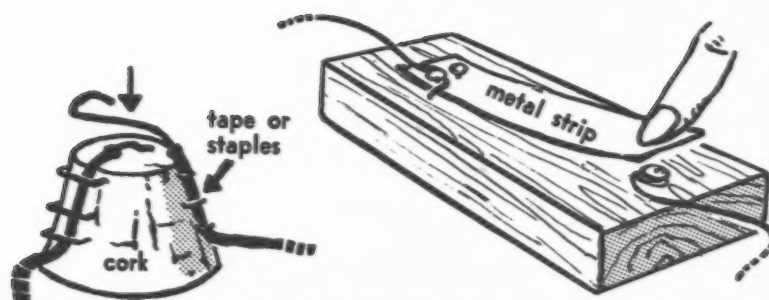
Dry cells used in science fair exhibits will deteriorate rapidly, if excessive current drains and short circuits are not avoided. A good rule to follow to prevent such waste is to place switches in every circuit. For bells and lights one may use knife switches or, preferably, pushbutton switches. However, since electromagnets give no audible or visible evidence of being activated, these should be controlled **ONLY BY PUSHBUTTON SWITCHES**. These switches are automatically in the OFF position when not in use.



A switch makes or breaks an electric circuit.

2. How can we make a bell or light go on and off?

Ask children to suggest ways of making the bell or light work. If they experiment with the materials and the circuit as in *Problem 1*, they will discover that when any wire is disconnected, the device stops working. (Electric equipment ceases to operate when the flow of electricity is interrupted.) Restoring the connection makes the device work again. A switch or pushbutton may be used to start or stop the flow of current, because it connects and disconnects the wires in a circuit. Connect a circuit using a knife switch as illustrated. Ask children to invent other



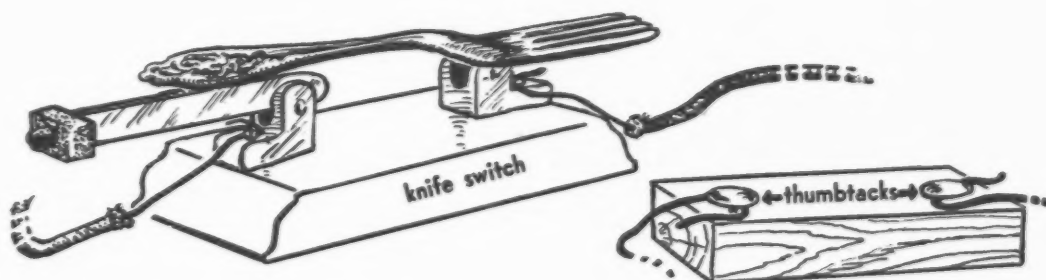
Two homemade switches.

ways of turning the devices on or off. This may lead to the construction of many kinds of switches. A few are shown in the illustration. The children should test all of these in circuits to judge their effectiveness.

- *We can make a bell ring or a light go on by completing a circuit.*
- *We can silence a bell or put out a light by breaking the circuit.*
- *A switch may be used to make or break an electrical circuit.*

3. Which substances carry electricity and which do not?

Ask the children to suggest answers to this question and to gather materials to be tested. Try paper, eraser, plastic button, key, coins, cloth, string, chalk, glass, nail, nail file, insulated wire, and bare wire. Ask children to devise a "tester" for determining whether or not a material will carry electricity. Allow them to develop their ideas and determine whether their invention works. One way is to test the material by placing it in a circuit with a light or bell across an open knife switch, or in a tester made with thumb tacks. If the light glows or the bell rings, the material carries electricity.



Using a switch to determine whether or not a substance can conduct electricity.

Call to the attention of the children that materials which carry electricity are called conductors. Materials which do not carry electricity are non-

conductors (insulators). The copper of a wire is a conductor; its covering is an insulator.

- *Metals conduct electricity well.*
- *Non-metallic materials such as rubber, cloth, plastic, and wood conduct electricity very poorly. They are insulators.*
- *Electric wire is commonly made of copper.*
- *Insulation prevents electricity from going where it is not wanted.*

4. How does a flashlight work?

Develop understanding on the part of the children that the flashlight is an electrical device which makes use of a switch, insulators and conductors, dry cells and a bulb.

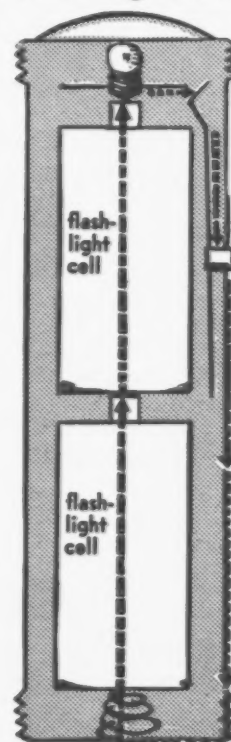
Discuss the uses of a flashlight in the home, in games, in Scout activities, in camp, by mechanics, doctors, motorists, janitors, policemen, and firemen. Encourage children to bring in various kinds of flashlights and take them apart, removing the bulb and the dry cells.



Discuss the function of each part. Ask children to make the bulb light without using the flashlight case. From the previous experiences with electric circuits they will probably ask for a *conductor* such as a wire to help them light the bulb. They may use a length of wire, as shown. After they succeed, they reassemble the flashlights.

Pupils may be challenged to find the circuit in a flashlight and to determine where the circuit is completed and broken.

The circuit in a flashlight.

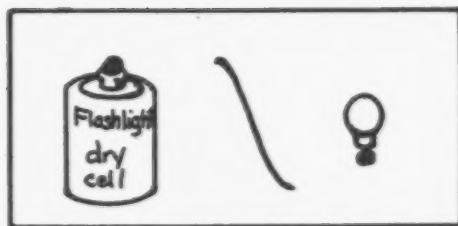


Note: In metal flashlights, the case is part of the circuit. In a two-cell flashlight, the cells must be inserted so that the bottom of one cell touches the top of the other in order to provide the proper electrical circuit. Allow children to try placing the cells in various positions to discover for themselves which way works best.

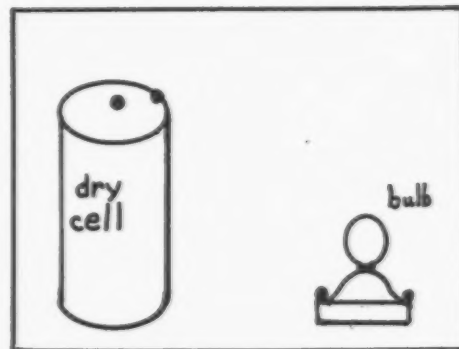
- *A flashlight contains an electric circuit controlled by a switch.*

EVALUATIVE ACTIVITIES

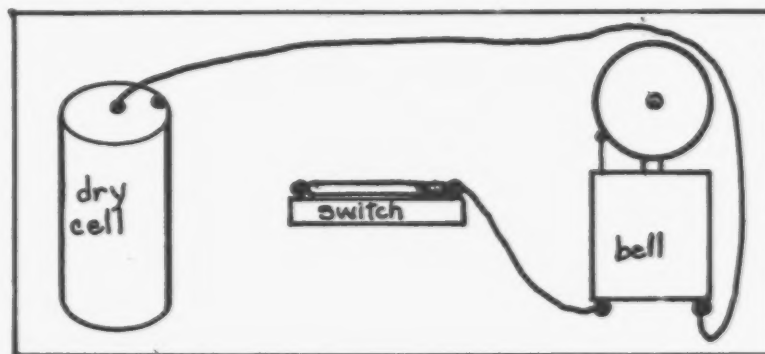
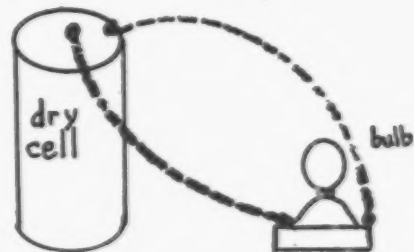
1. Have children complete the circuits by drawing pencil lines between the correct terminals (large dots).



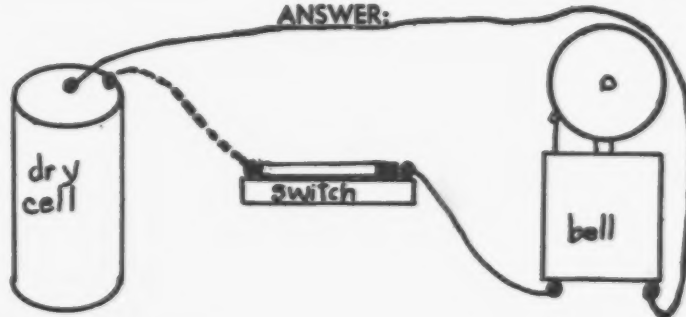
ANSWER:



ANSWER:

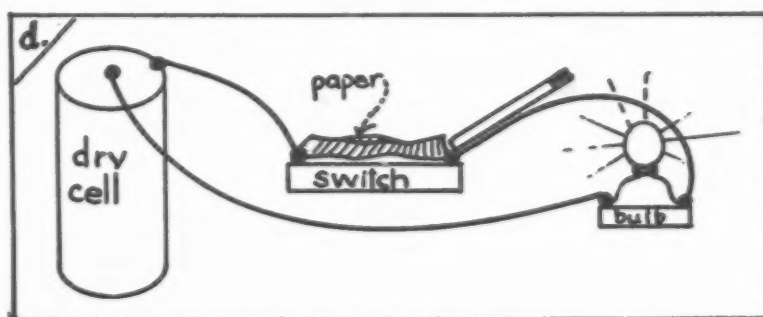
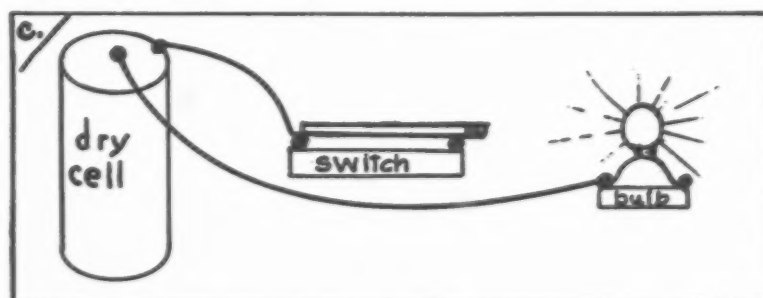
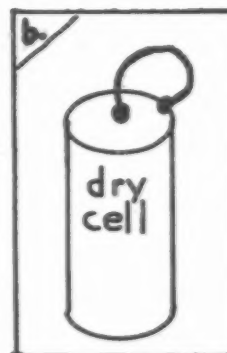
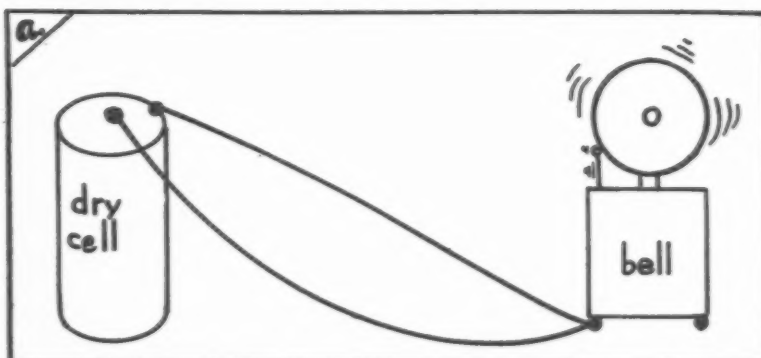


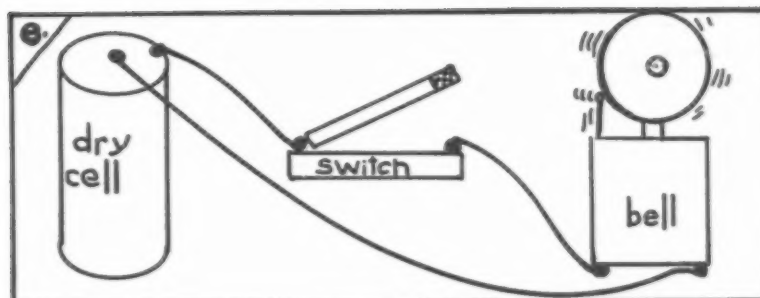
ANSWER:



2. Tell what is wrong with each picture.

- a) (Both wires go to the same terminal of the bell; one wire should be shifted to the other terminal; there is no circuit; the bell would not ring; there is a short circuit.)
- b) (The dry cell is short circuited; the wire will get very hot; you will spoil the dry cell.)
- c) (One wire is needed to connect the switch to the bulb; a wire is missing; the circuit is not completed.)
- d) (Paper will not carry electricity; the switch is not closed; the circuit is not complete; the bulb would not light.)
- e) (The switch is not closed; the bell would not ring; the circuit is not complete.)





3. Below is a list of materials. Some do and some do not conduct electricity. Put a circle around the materials which *do* conduct electricity well. (Brass key, iron nail, copper coin, aluminum foil, steel spring, gold chain, silver bracelet.)

wood	copper coin	silver bracelet
paper	aluminum foil	bread
brass key	water	rubber band
iron nail	steel spring	stone
plastic ring	gold chain	ordinary paint
rope	cloth	glass
leather	hair	felt

4. A boy connected a dry cell, a switch, and a bulb, but found that the bulb did not light.
- What might the trouble be?
 - How could you be sure? Below are some possible answers.

SOME ANSWERS

TROUBLE	HOW TO BE SURE
The bulb is broken.	Try a new bulb.
The bulb is not screwed in tightly.	Try screwing it in tightly.
The socket is broken.	Try a new socket.
The wires are loose.	Tighten all connections.
The dry cell is dead.	Try a fresh dry cell.
The boy forgot to take off the insulation from the outside of the wire.	Check this. If the insulation is not off, scrape it off.
The switch is not working.	See if the switch makes a tight connection or try another switch.
The boy did not make a circuit.	Check the wires. See if you can make the bulb light by changing them.

5. Show children a Motormite (a tiny motor with terminals, available from the *E-1 List*). Ask children to suggest or demonstrate how to connect a dry cell, switch, and wires to the motor to make it run. (Does the motor run? Do children apply the principle of a complete circuit?)

BASIC SUPPLY LIST FOR *ELECTRICITY IN EVERYDAY LIFE*

* Indicates quantity for entire class; other quantities
specified are for each group of 4 children.

E-1: Science Supply List

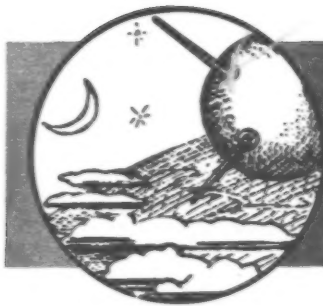
- | | |
|-------------------------|------------------|
| *1 Hot Plate | 4 Test Clips |
| 2 Bells | 4 ft. bare Wire |
| 20 ft. Annunciator Wire | 2 Knife Switches |
| 2 Miniature Lamps | 2 Push Buttons |
| 2 Miniature Sockets | 1 Motormite |
| 2 Battery Holders | 1 Dry cell |
| 1 roll Aluminum Foil | |

G-1: General Supply List

- | | |
|--------------------|----------------------|
| 2 Flashlight Cells | *Paper |
| 1 Flashlight | *Rubber Bands |
| 1—12" wooden Ruler | Thumb Tack |
| Chalk | *Ball of String |
| Eraser | (warp, thread white) |

Miscellaneous:

- | | |
|---|-------------------|
| Assorted metallic and
non-metallic Objects | copper Coins |
| plastic Buttons | pieces of Leather |
| iron Nails | Cloth |
| Nail File | glass Tumbler |
| Keys | String |



The Earth and the Sun

A. NIGHT AND DAY

Background for the Teacher

Long ago, people believed that the sun rose in the east, traveled across the sky and then sank down behind the land in the west. It is now known that the sun only *seems* to do this; it is really the earth which does the moving as it turns on its axis. It moves in the direction opposite to that in which the sun apparently moves. The sequence of day and night depends on this turning of the earth. Since the earth is round, the sun lights only the part that is turned toward it; people on that part of the earth experience *day*. On the part of the earth that is turned away from the sun people experience *night*.

Since the earth makes one complete turn in twenty-four hours, the sequence of day and night takes twenty-four hours. At the same time that the earth is spinning (rotating), it is traveling around the sun (revolving) in a path that is almost a circle. It is because our earth rotates on its axis $365\frac{1}{4}$ times as it makes one revolution around the sun that we have $365\frac{1}{4}$ days in a year.

Today no one questions the roundness of the earth. Aerial photographs taken by rockets and the observations of astronauts have provided us with a direct view of the earth.

It is important to understand that the rotation of the earth is a counterclockwise motion when viewed from a position in space "above" the North Pole. In turning a classroom globe in any of the activities which follow, the turning should always be *counterclockwise*. The revolution not only of the earth, but of all the planets in the solar system, is *counterclockwise*.

Since the earth turns on its axis once in twenty-four hours, a person standing at the equator travels a distance equal to the circumference of the earth, or 24,000 miles, in one day. His speed amounts to 24,000 miles divided by twenty-four hours, or about 1,000 miles per hour.

A person at the North Pole would not move at all in relation to the axis of the earth: the distance he travels is zero and his speed is zero miles per hour. A person in New York (which is located between the North Pole and the equator) travels only $14\frac{1}{2}$ thousand miles a day, or at a rate of about 600 miles per hour.

Approaches and Learnings for the Child

Children are aware of day and night but need help in understanding the basic causes of this daily cycle. The teacher guides them to more careful observation of the sun's apparent movement across the sky. They are encouraged, with the aid of models, to adopt a *space* view and to see the earth as a round body that is lighted by the sun.

From the activities suggested, children learn the following.

The earth is round.

The earth turns.

One half of the earth is lighted by the sun at any one time.

The turning of the earth brings day and night.

Day follows night; night follows day.

In one year, the earth moves around the sun once.

1. How does the earth look to an astronaut?

The purpose of this question is to encourage children to use their imagination about the earth in space, to help them review their knowledge, and to help them adopt a *space* viewpoint of the earth. Encourage a free and full discussion of this question.

The following questions may be useful in guiding discussion of the earth in space.

Does the earth look dark or light? (Part is dark and part is light.)

Which part is light? (The part the sun is shining on.)

Which part is dark? (The other side.)

How does the astronaut know which portion of the earth he is seeing? (By the continents and oceans he sees.)

What shape does the earth seem to have? (Curved.)

Can the astronaut see anything on the dark side of the earth? (Perhaps the glow from the electric lights of big cities.)

Does anything ever hide part of the earth from the astronaut's view?

(At times, clouds may or a man-made satellite or another space vehicle.)

What else might an astronaut see? (Other satellites, the moon, the sun, stars.)

The foregoing questions and others that may be asked by the children and the teacher need not be answered at this point, since the activities which follow will consider many of them in detail. It may be helpful to introduce a globe of the earth and to help children understand that when they look at it, they are having a kind of "space" view of a model of the earth.

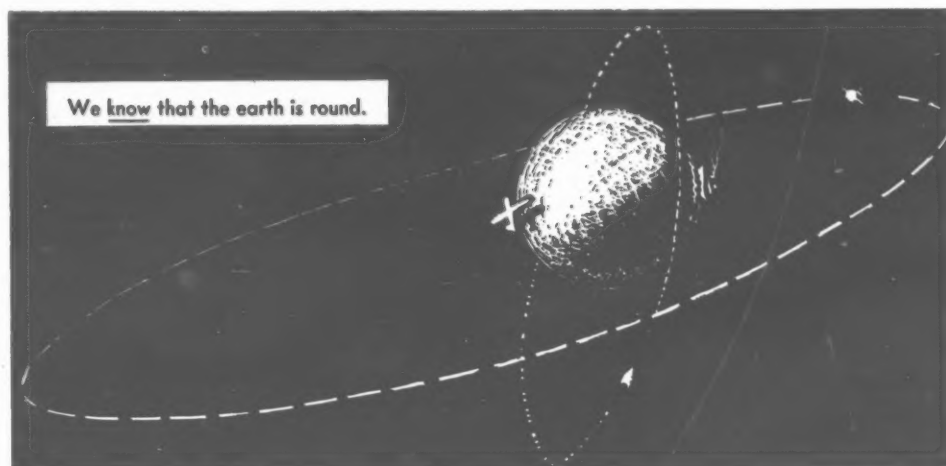
- *The earth is round.*
- *Part of the earth is dark and part is light at any one time.*
- *The earth does not rest on anything in space.*
- *The earth is in space.*
- *The sun shines on the earth.*

2. How do we know the earth is round?

Discuss this belief with the children. Perhaps they will suggest evidence they have heard of, such as: ships have sailed around the earth, airplanes have flown around the earth, satellites have gone around the earth, astronauts have gone around the earth, and high altitude photographs taken in rockets show the curvature of the earth.

Using a globe, develop the idea that it is a small model of the earth and that any ball can be used to represent the earth.

- *It has been found in many ways that the earth is round.*
- *A globe is a model of the earth.*



3. How much of the earth is lighted by the sun?

Shine a light on a globe or large ball. For this purpose the sunlight, a flashlight, a candle, or a projection machine may be used. Set up a globe and projection machine (or a flashlight) so that the globe is evenly lighted on one side by the beam of light. This will show up well if the projection machine is not too close to the globe. Move the globe back and forth until half of it is evenly lighted. The lens of the projection machine should be at the same height as the middle of the globe. Draw the shades in the room to increase the contrast between the lighted half and the dark half.

Children should be helped to understand that the globe represents the earth, that the flashlight, candle, or projection machine represents the sun and that the light from these sources represents the sunlight. Although the children see only the representational materials at this time, class discussion should help children arrive at the following understandings.

- *Half of the earth is lighted by the sun at one time.*
- *Half of the earth is not lighted by the sun at one time.*

4. Where do we have day? Where do we have night?

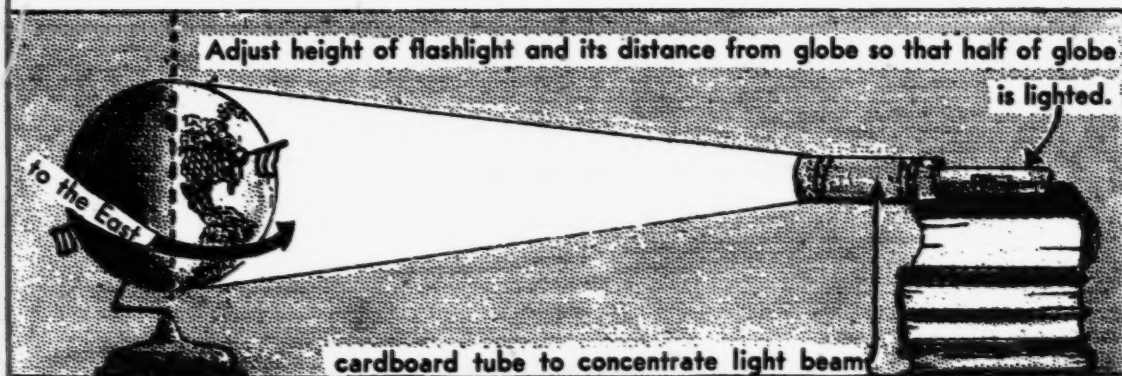
Place a globe near or on a window sill, or in any other part of the room where it is fully in the sunshine, or take the globe to a sunny place outdoors. Observe that one-half of the surface of the globe is lighted and that the other half is in the shade. Develop the idea that the part of the earth that is lighted has day while the part in the dark has night. If it is not feasible to do this in sunlight, use a flashlight or projection machine to represent the sun, setting up the model as in *Problem 3*.

- *The half of the earth facing the sun is lighted up; this part has day.*
- *The half of the earth away from the sun is not lighted up; this part has night.*

5. When it is daytime for us, what is it for people on the other side of the earth?

Indicate where New York City is on a geographic globe. Mark this spot in any convenient way. Indicate a similar spot on the other side of the earth (Tokyo). Mark this so that the two may be easily distinguished.

Place the globe in sunlight. If this isn't feasible, set up a model such as the one used in *Problem 3*. Begin by putting "New York City" in sunlight. Develop the idea that we have day at this time and that, at the same time, the spot on the other side of the earth has night. Turn the globe slowly (counterclockwise as seen from above) until New



Demonstrating night and day.

York City is turned away from the sun and the spot marked opposite it is now in the sun. Repeat this a number of times. The children will see that when we have day, the people on the other side of the earth have night. When we have night, they have day.

- *When we have day, the opposite side of the earth has night.*
- *When we have night, the opposite side of the earth has day.*

6. Why does day follow night? Why does night follow day?

Set up a globe in full sunlight. (Do this outdoors, if necessary.) Turn the globe slowly (counterclockwise as viewed from above) while the class observes that the part which is in the sunlight moves into the shade (night) and the part in the shade moves into the light (day). An alternate method may be to set up the model as in *Problem 3*.

The children should be made aware of the fact that the light source (sun) is not moving and that the globe (earth) is rotating. This motion of the earth makes it *appear* as though the sun were moving across the sky.

- *As the earth turns, the part which faces the sun has day, the part away from the sun has night.*
- *Day follows night, night follows day, because the earth is turning and only one-half of the earth is lighted at one time.*
- *One complete turn of the earth takes twenty-four hours.*

7. At different times during the day where does the sun appear in the sky?

Take the children into the school yard at nine o'clock, at noon, and at three o'clock to note the position of the sun in the sky at these or other convenient times. Repeat at the same times for several days in succession. These observations can also be noted by observing the position of the

sun from a classroom window. Review the idea that the sun *does not* actually move. As the earth turns the sun appears to move.

- *The sun appears low in the east in the morning.*
- *The sun appears highest in the sky at noon.*
- *The sun appears low in the west in late afternoon.*
- *Because the earth turns steadily, the sun seems to move across the sky each day.*

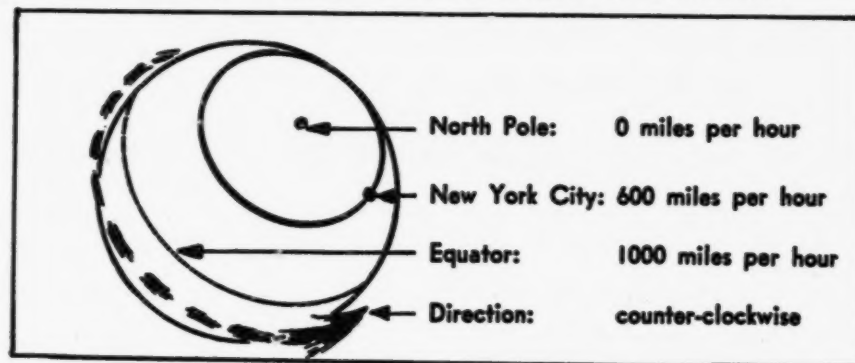
8. How many miles do ~~you~~ travel during one turn of the earth?

Discuss with the children that our earth turns (rotates) in a silent, steady path around its axis; that we are turning at a speed of about 600 miles per hour in New York City. Ask children to tell at what speeds they have travelled in the family car, in a train or airplane. Discussion may lead children to understand that we do not feel this rapid motion of the earth because it is so even and smooth and because everything else on earth—even the air—moves along with us. We would feel the motion if there were a sudden increase or decrease in speed. Children recall experiences of sudden stops and starts in subway trains or buses.

Where on earth are people rotated faster than in New York? (Nearer to the equator.) More slowly than in New York? (Nearer to the poles.) Where on earth are people being rotated more slowly? (Near the poles.)

Note: Some children may also know that while the earth is rotating, it is also moving in a path around the sun. The second motion of the earth is called *revolution*. The earth moves at the average rate of 66,600 miles an hour around the sun. The length of time that it takes for the earth to go around the sun once is called a year. Ask the children how many trips they have taken around the sun. (The answer is equivalent to their chronological age.)

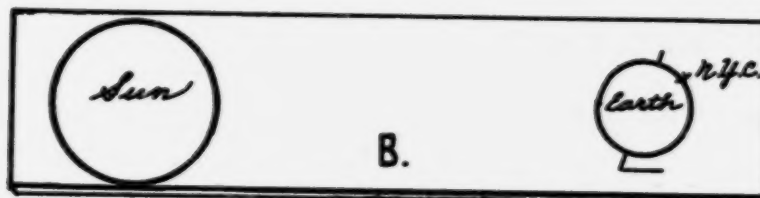
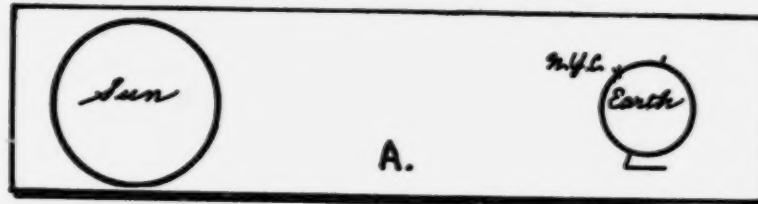
- *The earth rotates at a steady speed.*
- *In New York City we rotate at a speed of 600 miles an hour.*



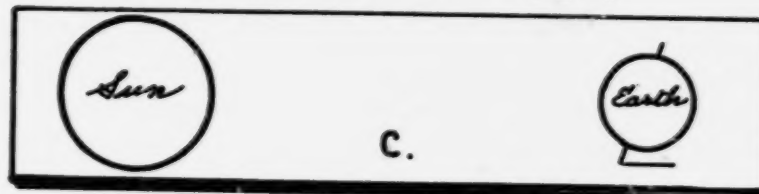
The distance travelled depends on where you are.

EVALUATIVE ACTIVITIES

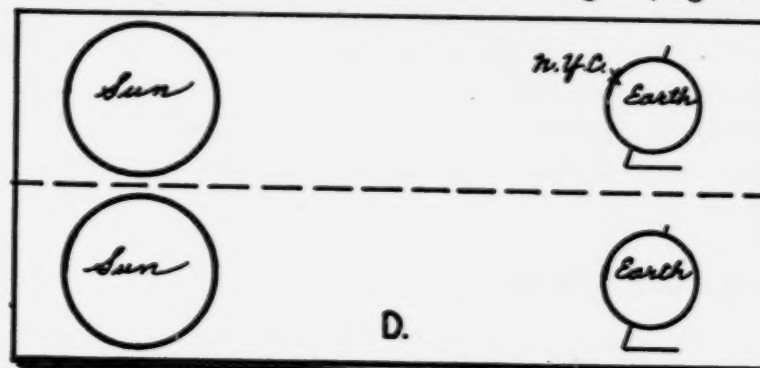
1. In picture A, is it day or night in New York? (Day.)



2. In picture B, is it day or night in New York? (Night.)



3. In picture C, color the part of the earth that has night. (Right-hand side.)



4. In picture D, the upper drawing shows where New York City is at noon. On the lower drawing, mark an "X" to show where New York City would be at 12 midnight. (Near the right edge.)
5. Take children outdoors on the morning of a sunny day. If possible, have them sit in a circle in a suitable place. Ask them to point to the sun. Ask: Where was the sun earlier this morning? (Children point lower in the sky and farther east.) Where will the sun be later this morning? (Children point higher in the sky and farther west.) Where will the sun be later in the afternoon? (Children point lower in the sky and farther west.) Where will the sun be when it sets? (Children point to the western horizon.)

Where will the sun rise tomorrow morning? (They point to the eastern horizon.) Which way does the sun seem to move? (They span the sky from east to west.) Is the sun moving? (No.) What makes it *seem* to move? (The earth is turning.) Which way does the earth turn? (Children span the sky from west to east.) Can you feel the earth turning? (No.) Why not? (It and all on it turn smoothly and steadily.) How fast are we moving on the earth? (600 miles per hour; as fast as a jet plane.) Why don't we feel a breeze? (The air turns with the earth.)

B. TELLING TIME

Background for the Teacher

The motions of the earth give us two of our units of time—the day and the year. The period of time required for the earth to rotate once on its axis (see page 41) gives us our day. The interval during which the earth revolves around the sun gives us our year.

Man's need to measure time in units smaller than a year or a day led to the invention of various devices, such as the sundial, the hourglass, the clepsydra or water clock, and the marked candle. These made it possible to measure off smaller periods of time such as the hour, which represents $1/24$ of a day. Present-day watches and clocks are made to go by springs, or pulses of electricity, which keep the mechanism moving at an unchanging rate. It is therefore possible to reduce the time intervals to minutes and seconds. The most accurate device for measuring time, however, is the atomic clock. This clock "ticks" billions of times each second and is regulated by the "wobble" of atoms of the element called cesium.

Approaches and Learnings for the Child

Children are familiar with the many kinds of mechanical and electrical watches and clocks commonly used for measuring time. The experiences in this topic will help children to appreciate such ancient time devices as the hourglass, the water clock (clepsydra) and the marked candle. They will also understand that the measurement of the larger units of time—the day and the year—have their origin in the movement of astronomical bodies.

From the activities suggested, children learn the following.

The earth's steady turning makes it a kind of clock.

Clocks and watches are made to run by various methods.

Clocks and watches of today are more accurate than those of the past.

1. How do we tell time?

Ask children, after securing permission from home, to bring in a variety of commonly used watches and clocks. (An expensive or rare timepiece should not be brought to school unless a parent wishes to deliver it, show it and then take it back.) These may include some of the following: wrist and pocket watches, clock radios, self-winding watches, electric and transistor clocks, travel clocks, cuckoo and alarm clocks.

They may also bring in pictures of unusual time-keeping devices. Some of these may include grandfather clocks and clocks on famous buildings.

What makes the clock go? Discuss springs, electric motors, and falling weights (as in cuckoo clocks).

- *Today we use clocks and watches for telling time.*
- *Clocks and watches come in different sizes and shapes.*
- *Clocks and watches are made to run by various methods.*
- *Clocks and watches today are more accurate than those of the past.*

2. Is the earth a clock?

This unusual question should stimulate children to compare the earth with a clock. They know that something in a clock makes the hands move smoothly and steadily. It takes one hour for the minute hand to make a full turn. It takes twelve hours for the hour hand to make a full turn.

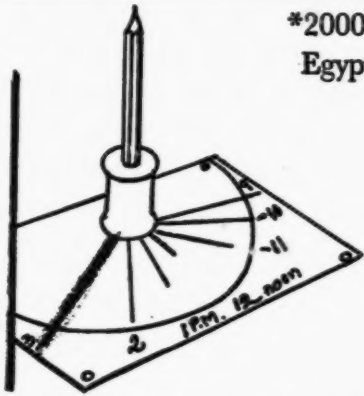
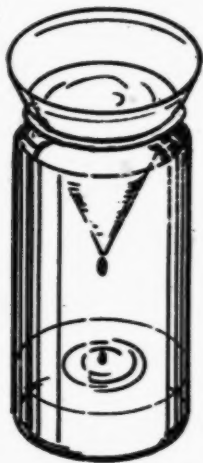
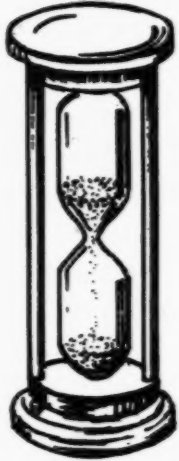
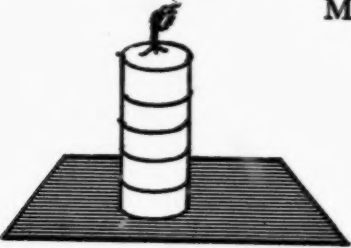
Does the earth turn steadily? (Yes.) How long does it take to make a whole turn? (A day of 24 hours.) Does the earth show each hour? (No.) How can we know the hour? (We use a clock of some kind.)

- *The earth's steady turning makes it a kind of clock.*
- *One turn gives us a full day.*
- *We have divided this day into 24 hours.*

3. How did people tell time long ago?

Children will recall their Grade 2 experiences with shadow sticks. (See *Science: Grades K-2*, pages 192-193.) Otherwise teach *Problems 6 and 7* on those pages.

Discuss with children why, all through the ages, people had to find ways of telling time. Ask the children to name other devices used over the years to tell time. Encourage them to build their own simple devices. The next page shows a few they can make. Have the children compare the accuracy of these devices with that of clocks or watches.

TYPE OF CLOCK	WHEN USED	HOW TO MAKE IT
sundial 	*2000 B.C., by Egyptians	The sundial works on the principle of the shadow stick. The hours of the day are marked off on the dial.
water clock 	*850 B.C., by Egyptians, Phoenicians, and Chinese	Make a small opening in a cone-shaped paper cup. Mark off equal distances on the glass jar. Pour water into cup. <i>Note:</i> Size of hole will determine how much water will drip into glass jar in a given time.
hourglass 	*750 A.D.—Middle Ages	Ask children to bring in hourglasses from home (egg-timers). How long does it take for each to empty? Check with a clock. When they are turned over, do they take same length of time to empty?
candle clock 	*870 A.D.—Middle Ages	Mark off equal distances on a candle. (The thicker the candle, the longer it will take to burn from one mark to another.)

* for teacher's information only.

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Why are these old clocks impractical today? As they make and use these devices, children will discover that they are not dependable; they need to be watched; corrections have to be made constantly; their timing is not uniform. Have children compare the "old time" clocks they make with a modern timepiece for accuracy. Ask them to express their findings mathematically. For example, they may find that their water clock gives the following readings.

First emptying: 10 minutes
Second emptying: 11 minutes
Third emptying: 9 minutes
Fourth emptying: 9 minutes etc.

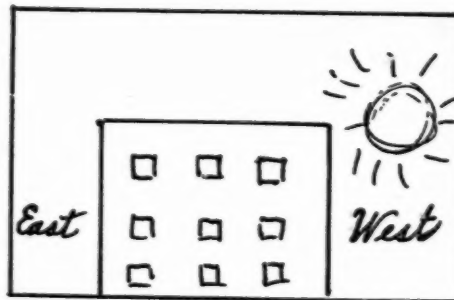
What might cause the differences in the readings? (Change in size of hole in paper cup; water evaporates.) How accurate is the candle clock? Burn several and see.

- Long ago men found it necessary to tell time.
- People used many different devices for telling time.
- These devices were not as accurate as today's clocks and watches.

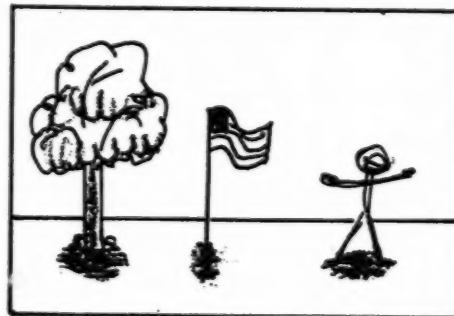
EVALUATIVE ACTIVITIES

1. Look at the picture below.

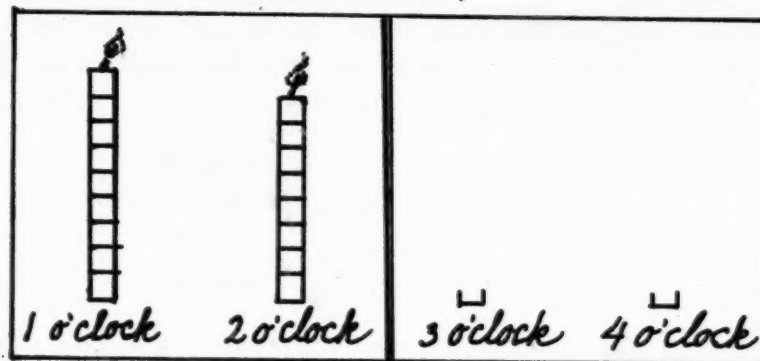
Would you be going to school or coming home at this time? (Home.)
How do you know? (The sun is in the west in the afternoon.)



2. What time of day do you think the picture below shows? (Around noon.)
Why? (Shadows are small when the sun is overhead, and this occurs at noon.)



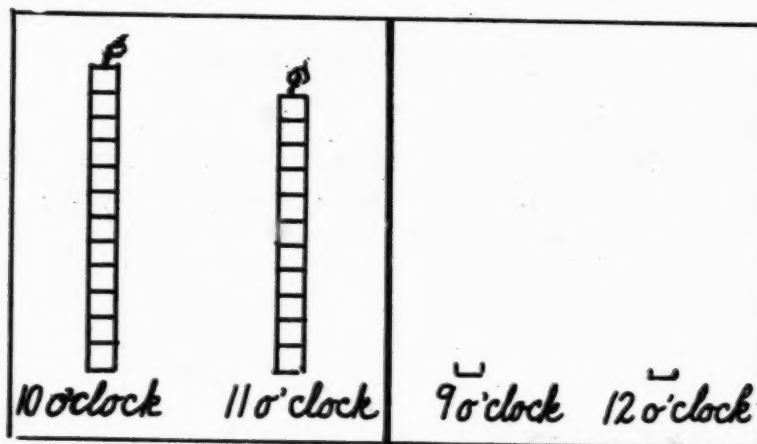
3. The pictures below show how a marked burning candle looked at one o'clock and at two o'clock. Draw it the way you think it will look at 3 o'clock and 4 o'clock. (One level shorter for each hour.)



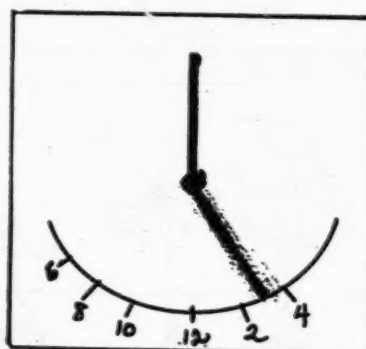
4. The pictures below show how a marked, burning candle looks at 10 o'clock and at 11 o'clock.

Draw it the way you think it looked at 9 o'clock. (One level higher than at 10 o'clock.)

Draw it the way you think it will look at 12 o'clock. (One level lower than at 11 o'clock.)



5. About what time is it when your shadow clock looks like the picture below? (3 P.M.)



6. A class made a water clock. The children compared the readings with the electric clock in their classroom. After a few hours, the time on the two clocks did not agree. What might have happened? (Some water may have evaporated; the cup may have torn; the hole may have become enlarged; perhaps there were other reasons why the water clock was not as accurate as the electric clock; the electric clock might not be working properly.)

BASIC SUPPLY LIST FOR THE EARTH AND THE SUN

* Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- *Geographic Globe
- 4 Candles
- 2 lbs. Sand

G-1: General Supply List

- *Flashlight
- 4 Pencils
- 4 sheets 9" x 12" Drawing Paper

Miscellaneous:

- | | |
|-----------------------------|---------------------------------|
| *large Ball | *Clock Radio |
| *Projection Machine | *Self-winding Watch |
| assorted Clocks and Watches | *Electric and Transistor Clocks |
| 4 empty Spools | *Travel Clock |
| 12 cone-shaped Paper Cups | *Cuckoo and Alarm Clock |
| 4 glass Jars | |



The Needs of Plants and Animals

A. THE NEEDS OF PLANTS

Background for the Teacher

A green plant requires light, minerals, air (oxygen), water, and suitable temperature in order to thrive. Each part of a plant—the roots, the stem, and the leaves—has specific functions which enable a plant to satisfy these requirements. In addition, flowers are essential for the reproduction of new plants.

Attached to the smaller divisions of the roots are many tiny root hairs. In the ground the root hairs come in close contact with tiny particles of soil. Water dissolves some of the minerals in the soil. The dissolved material goes through the thin walls of the root hairs and into the roots. Roots also serve to anchor a plant from being blown over by strong winds, or from toppling over because of their own weight.

The stem of a plant carries water and minerals from the roots to the leaves. It also carries manufactured foods from the leaves to the flowers and roots. In addition, the stem also holds the leaves of a plant up to the light.

The leaves of a plant make the food for the plant. Water from the soil and carbon dioxide gas from the air are combined in the leaves by chemical activity to form sugar. Chlorophyll, the green-coloring material in leaves, must be present for this reaction to take place. Sunlight provides the energy needed to sustain this process of food-making (photosynthesis) in green plants. One by-product resulting from photosynthesis is oxygen, which is released into the air and enriches the atmosphere for all life.

Sugars may be later converted into starches and fats. Minerals combine with some of the sugar to form proteins and many plant products.

The flower contains the reproductive organs of the plant which make the sperm and eggs. The flower also facilitates the union of these sex cells which form the embryo plant inside the seed.

Approaches and Learnings for the Child

One of the best ways for children to understand the needs of plants is to grow them. In so doing, they obtain visible and almost immediate evidence that living things grow and have certain requirements for growth. The school garden (see *The School Garden in the Science Program*, page 18) should be regarded as an important annex to the classroom in which to teach and learn about plants.

As children work with plants they learn how to plan carefully conducted experiments in which one, and only one, condition (e.g. light, or water, or air) is tested at a time on a number of plants. In this way they can be more certain that the results they observe are caused *only* by the variation in that one condition (e.g. light versus no light).

From the activities suggested, children learn the following.

Green plants need light, water, air, proper soil, and correct temperature to grow.

Plants vary in amount of light, water, air, and kind of soil needed.

Each part of a plant helps it to live and to grow.

Note: For the experiences in the following unit, a number of inexpensive, expendable plants are required. Hardy seedlings can be grown quickly from lima and kidney beans as well as from seeds such as zinnia and sunflower. (Mung beans, obtainable from Chinese grocery stores, are particularly hardy.) These should be started well in advance of the science work on the *Needs of Plants*.

1. What do green plants need in order to live and grow?

Have children tell what care their plants receive at home and in school. Ask them to list the conditions they think necessary to keep the plants alive and growing well. Make a chart of the conditions suggested. Keep it as a guide for the children as they explore the needs of plants. At the completion of the topic, children can refer back to the chart to see if their original list was correct and complete. It might look like this:

To live and grow, a green plant needs	
water	light
soil	air
proper temperature	

- *Green plants need water, soil, light, and air, and a suitable temperature to live and grow.*

2. How can we find out if plants need water?

Ask children to devise experiments to find out if plants need water. They may suggest depriving a few plants of water for several days while other identical plants are watered regularly for comparison. Have them make drawings of the two sets of plants to record the changes that occur. Plants suitable for classroom use include ivy, coleus, geranium, tradescantia, pothos, and begonia.

Develop with the children a plan for conducting the experiment. For example, three geranium plants which are watered regularly may be compared with three geranium plants of approximately the same size (and vigor or health) which are deprived of water. They should understand *why* conditions throughout these experiments must be the same for all plants being compared. They should come to realize that if some of the plants are grown in a cool part of the room and some in a warm part, the differences observed may be caused by variations in temperature rather than in water supply. The size of the pot, the amount of soil, and the amount of sunlight and temperature must be constant.

Note: The same care should be used in any problem which involves the testing of an experimental condition.

- *Experiments help us find answers to questions.*
- *Plants need water to live.*

3. How can we save these wilted plants?

Using the plants which received too little water in Problem 2, have the children note the condition of the leaves and stems. Now water the plants thoroughly and watch them for a number of days. Before-and-after drawings made by the children will be useful.

- *A wilted plant may be saved if we use water in time.*

4. Can a potted plant get too much water?

To answer this question children are asked to design experiments to determine what happens to plants when they are given different amounts of water. They may suggest using a number of identical plants, as in Problem 2. (This time, use expendable potted plants such as bean seedlings.)

Two plants receive the usual amount of water; two are given twice as much water; and two are given three times as much water as the "normal" group. A record should be kept of the amount of water given—e.g., 1 cup; 2 cups; 3 cups. Each plant should be placed in a deep

dish to prevent the water from running over. As in Problem 2, all *other* conditions should be the same for all plants. Compare the appearance of all three groups of plants. What differences, if any, are there in the leaves? What happens to the stem? Has anything happened to the soil? From the results observed, have the children decide on a plan to save the poorer plants.

- *Too much water is harmful to potted plants.*
- *Plants need the right amount of water to live.*

5. Why do plants grow poorly in soil which is kept soaked?

This question may arise from the previous problem. It may help children if they are asked: "What happens to soil when it is soaked in water?" Some may recall a demonstration performed in Grade 2 (*Science K-2*, pages 232 and 233), in which a clump of soil is submerged in a jar of water. Air bubbles are observed escaping from the soil. If the children do not recall this experience, have them try it.

Discuss with children that air is essential for a healthy root system. If the soil is kept soaked, air is kept out.

- *There is air in soil.*
- *The roots of plants need air.*

6. How can we find out whether green plants need light?

Children may suggest the following techniques.

- a. Place several plants in a dark closet. Water the plants and observe what happens to the leaves and stems from day to day. Compare with similar plants kept in the light and receiving the same care.
- b. Another way to test the effect of the absence of light is to wrap a few entire branches of a plant loosely with aluminum foil to exclude light and leave the other branches of the plant uncovered. After several days of the usual care, compare the uncovered portion of the plant with the covered portion.
- c. Still another way is to cover a small plant with a paper bag. Water it and observe it for several days. Compare it with uncovered plants of the same kind, receiving the same care.

Note: In each of the three preceding methods, a question may be raised with respect to the *air supply*. Since neither the closet, the foil wrapping, nor the paper bag are airtight, it may be assumed that air reaches all plants under the experimental conditions. Some children may con-

tend that the *temperature* of the closet is different from that outside. Record the temperature at intervals and see if there is a difference. If children insist that differences in air supply or in temperature may influence the experiment — despite the best efforts to control these factors — they should be encouraged to maintain that reservation.

- *Green plants need light to live.*

7. Why are some potted plants turned around every few days?

Notice the position of the leaves of plants in the classroom. Find a plant with leaves that face the sunlight. A geranium plant is good for this purpose. Turn the pot so that the leaves face away from the window. See if the leaves will turn toward the light again. How long does it take to complete their turning? Compare with a similar geranium plant which has *not* been turned around.

- *Leaves turn toward the light.*

8. How can we find out if all green plants need direct sunshine to live?

Take the class for a walk to look for plants that grow in shade and receive little or no direct sunlight. Some children may be assigned to check on these observations at different times of the day to determine if the plants receive *any* sunlight. Look for such plants under large trees, against the north wall of a building, or under dense hedges.

Grow plants such as ivy, pothos, nephthytis and bryopyllum in a north window.

- *Some plants live where there is little or no direct sunlight.*

9. Do plants grow better in sand or in soil?

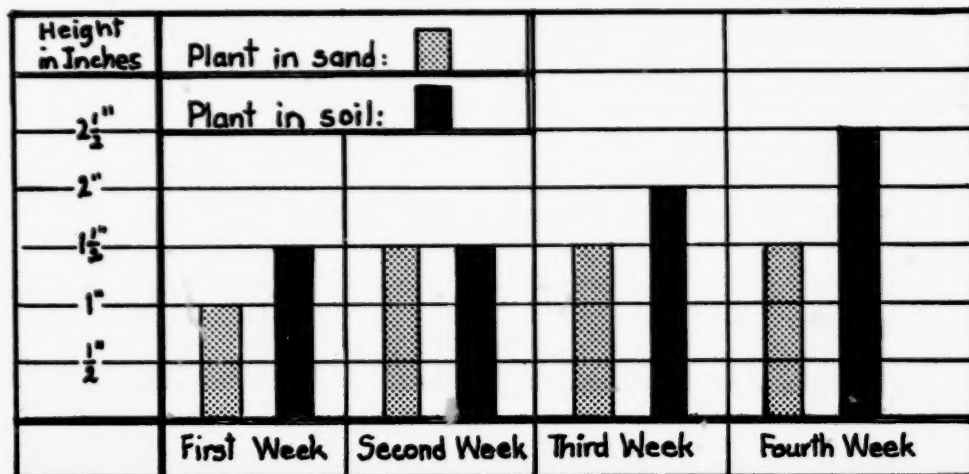
Ask children to help design an experiment to determine the answer to this question. Obtain several flower pots of the same size. Fill some with soil and an equal number with sand. Plant several seeds or transplant seedlings of the same type and size into each of the containers. Provide the same conditions of moisture, temperature, and light for both. Compare both for rate of growth and general appearance. Observe and record on a chart the size and appearance of both plants after each week. Continue for a month or more. If necessary, support seedlings with suitable sticks.

This activity offers the children an opportunity for developing a bar graph such as the one shown below. Measure the height of each plant

GRADE THREE

each week with strips of colored paper cut to the height of the plant. For example, red for plants in sand, blue for plants in soil. Paste the strips in the proper column on an oaktag chart.

- *Plants usually grow better in soil than in sand.*
- *Soil contains materials (minerals) that plants need for growth.*



Comparing growth of plants in sand and in soil.

10. How can we grow healthy plants in sand?

Obtain several flower pots of equal size. Line the bottom of each pot with a thick blotter. Fill each pot with the same amount of sand. Plant several seeds or transplant seedlings of the same type and size into each of the pots. Maintain the same conditions of moisture, temperature, and light for both. Observe the growth and appearance of the plants at regular intervals. When plants begin to look less hardy, ask children what must be added to the sand to help the plants. Refer to the previous experience (Problem 9) with sand and soil.

Children may suggest adding minerals in the form of a fertilizer. There are commercially prepared plant "nutrients" available in flower stores which contain the minerals needed for the growth of plants. Follow the directions given with these preparations. Add fertilizer to half of the potted plants and keep the others as "controls." Have children keep records, at regular intervals, of the appearance and growth of each plant. Prepare a chart similar to the one used in Problem 9, comparing *Plant in Sand with Fertilizer* with *Plant in Sand*.

- *Plants can be grown in sand if fertilizer is added.*
- *Fertilizers contain minerals that plants need for their growth.*

11. What happens to our potted plants when they are exposed to extreme cold?

Plants left in school during long weekends or vacations in the winter time are a source of concern to teachers and children. Ask children how they can find out whether very cold temperatures affect their potted plants. Where should they put these plants to find out?

Children may suggest placing the plant on a cold window sill or other cold area in the building. After the weekend or vacation, children examine the plant to see what changes have taken place in its appearance and condition.

If feasible, place a small potted plant in a closed container, such as a plastic bag, and keep it in a refrigerator overnight. Compare it with a similar plant which was kept in a container at room temperature. Does the "cold" plant make a recovery after its exposure?

Ask children to suggest different ways of protecting the plants in the classroom during cold week-ends. Some children may want to put them in a closet. Others may suggest placing them in a carton away from the window sill. Still others may suggest covering them as illustrated below.



**Protecting plants during cold weekends
with plastic held up by dowels in clay.**

Use the various procedures suggested by the children and check to see which are effective in protecting the plants.

- *Cold temperatures are harmful to our potted plants.*
- *Plants can be protected from the cold in various ways.*

12. How do roots help a bulb to grow?

Have children plant paper-white narcissus or onion bulbs in pebbles, in clear glass or plastic containers. Add water as needed and keep in a dark

place. To avoid having the bulb decay, be sure it is not completely immersed in water. Have children observe the roots every few days, and record the development of a strong root network. When this occurs, the plant may be brought into the light. Children will observe how the network of roots anchors the plant. In what other way do roots help the plant? Is the bulb growing a stem?

- *Roots hold a plant in place.*
- *Roots take in water.*

13. Is it better to start bulbs in the light or in the dark?

Children may suggest starting some bulbs in the dark (as in Problem 12), and some in the light. When the bulbs grown in the dark have developed a good root system, they should be removed from the dark and compared with those grown in the light for a period of several weeks.

After the experiment has been set up, ask the children to make a checklist of items to be observed during the growth period. A typical list might include:

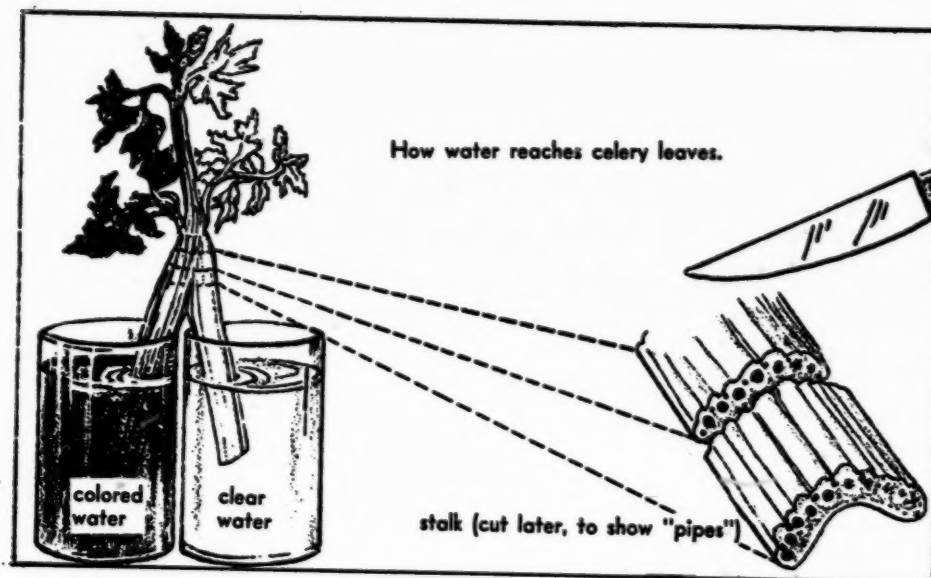
- When do the first roots appear in each group?
- Which group appears to have the largest growth of roots at the end of one week; two weeks?
- When do the first stems appear in each group?
- In which group do the stems go higher?
- In which group do flowers appear first?
- Which group has the best flower growth?

Understandings are not given for this problem because the results may vary somewhat, depending on the particular conditions of the experiment.

14. What does a stem do for a plant?

On a walk observe how the trunks and branches of trees hold leaves up to the light. Note how the trunk in trees and the stems in smaller plants supports the rest of the plant. Have children find plants with broken stems or branches. Observe leaves that are wilted or changing color, or dried-up buds which show that the part beyond the break in the living plant is dead or dying.

To demonstrate the water-carrying role of a stem, cut the end off a celery stalk, split it part way and put it in water colored with ink and



in clear water, as shown in the illustration. The color acts as a "tracer," enabling us to see the path that the water takes. After some of the leaves change color, cut the stem across in various places to see the "pipes" which carried the water.

- *Stems hold leaves up to the light.*
- *"Pipes" or tubes in the stem carry water from the roots up to the leaves.*
- *Plants are injured or killed when stems are broken.*

15. What do leaves do for a plant?

Start a number of bean plants growing from seeds. Plant the seeds in soil, in clear plastic containers. Children should notice that the two halves of the original bean ("seed leaves") become smaller and smaller as roots, stem and leaves develop. Why does this happen? (The food stored in the seed halves is used by each part of the developing plant.) What finally happens to the seed halves? (They wither and drop off.) What is happening to the true leaves of the plant at the same time? (They are growing larger; there are more of them; they develop a dark green color.) Where does the developing plant get its food now? (Children may say that the plant takes in minerals and water from the soil. This is true, but it is not the complete answer. The teacher may have to explain that the leaves of the plant use the minerals and water to *make food* for the plant.)

What would happen if most or all the leaves of a plant were removed? Have children set up an experiment with a number of bean plants in

which a varying number of leaves are removed from different plants. Observe the plants at frequent intervals. Have children keep records of their observations.

- *Leaves make food for the plant.*
- *The loss of many leaves during the growing season may injure or kill a plant.*

16. How can we use our school garden to learn about the needs of plants?

From the previous activities in their classroom, children have learned the conditions necessary for a plant to live. Growing a crop of plants for their flowers or for food, gives children the opportunity to apply some of the results of their indoor experiments to the practices and problems of gardening. (See *The School Garden in the Science Program*, page 18.)

The needs of plants—light, water, air, proper temperature, good soil—are seen on a larger, more practical scale in the school garden. Individual and group decisions have to be made which will influence the success of the undertaking. Some questions which may serve as a guide in the making of these decisions are:

What kinds of plants should we grow?

Will the plants receive light?

What part of the garden would be best for growing plants?

Is the soil good? Can we make it better?

When should we plant the seeds?

How should we plant the seeds?

How far apart should the rows and individual plants be?

Do we have to water our plants, or can we rely on the rain?

When will we harvest the crop?

What should we do with the crop?

Who should be responsible for each job?

How shall we protect our garden?

- *Green plants need light, water, air, proper temperature and good soil to grow.*
- *Some kinds of plants grow more quickly than others.*
- *Some kinds of plants need more sunlight than others.*
- *Most garden plants grow better in loose soil than in hard packed soil.*
- *We grow some garden plants for their flowers and some for food.*

EVALUATIVE ACTIVITIES

1. The part of the plant marked (a) is a (Leaf.)

What is part (b) called? (Stem.)

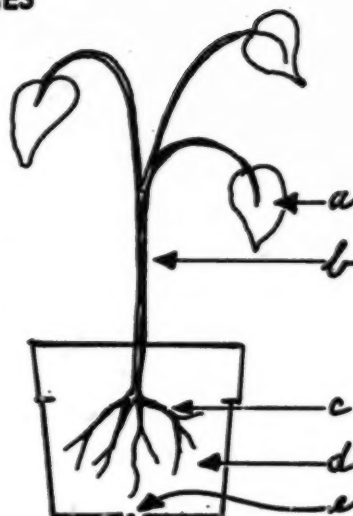
Part (c) is known as the (Roots.)

Name the part of a plant which holds it in the earth. (Roots.)

Name the part of a plant which brings water up to the leaves. (Stem.)

What is the use of the hole in the flowerpot that is marked (e)? (For water to run out; drainage.)

What is (d)? (Soil.)



2. What supplies the plant with minerals? (Soil; fertilizer.)

Which part of a plant takes in water and dissolved minerals? (Roots.)

Which part of a plant grows best in darkness? (Roots.)

Which part of a plant turns toward sunlight? (Leaves.)

Which part holds a plant up to sunlight? (Stem.)

Chemicals which are added to the earth are called (Minerals.)

What will happen to a plant if you stop watering it? (Dies.)

What will happen to a house plant if it is placed in the refrigerator? (Dies.)

Most plants will not grow in soil which is always soaked with water because the water keeps from the roots (Air.)

3. A boy wanted to find out whether a geranium plant needs sunlight in order to live. He carefully placed a healthy geranium in a place where it would get sunlight. Then, for comparison, he placed a healthy ivy plant in a dark closet. He recorded his observation of both plants for two weeks. He decided that a geranium needs sunlight in order to live.

Is this a good scientific experiment? Give reasons for your answer. (No. He should have used the *same kind* of plant in the dark and the light, and he should have used a *number* of plants in each place.)

4. Observe changes in attitudes and behavior of children as suggested in the following.

Do children appear to have a greater interest in plants?

Are children more concerned with the care and attention that is given to classroom plants?

Do children seem to be growing plants on their own at home?

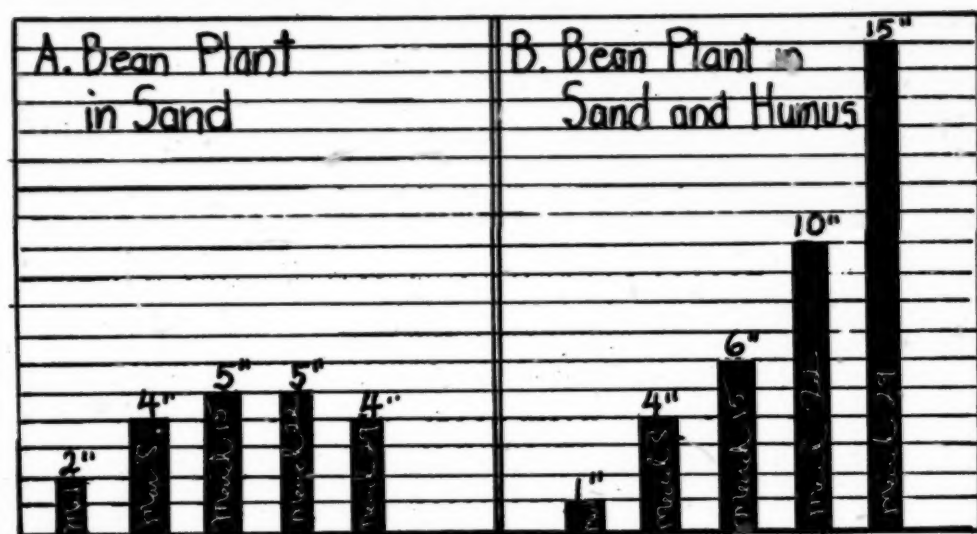
Are children more observant of the trees and shrubery around the school?

Do children report on their observations of plants in the neighborhood and nearby parks?

Do children visit local gardens, parks, botanical gardens, and flower shows on their own or with their families?

5. A boy planted a bean seed in a pot of sand (Plant A) and another bean seed in a pot of sand mixed with humus (Plant B). He watered both plants equally and placed both in the sunlight. He cut strips of paper to show how high each plant was at the end of each week. The graphs below show how each plant grew.

- Which plant was taller on March 1st? (Plant A.)
- Did Plant B ever catch up with Plant A? (Yes.) When? (March 8.)
- When did Plant A fall behind? (March 15.)

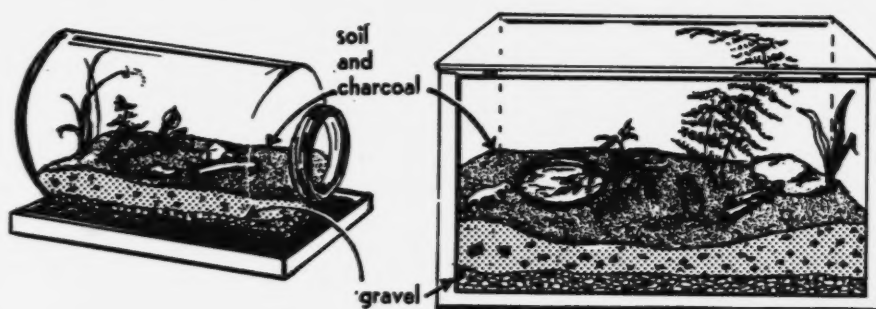


- When did Plant B grow most rapidly? (Between March 22 and March 29.)
- When did Plant A stop growing? (Between March 15 and March 22.)
- When did Plant A start to become shorter? (March 29.) What may be happening to it? (It may be dying.)
- How might Plant A be made to grow again? (Add fertilizer; humus; plant food.)
- Make a drawing of how high you think Plant B will be on April 5? (Taller.)
- What conclusion could the boy draw from his experiment? (The bean plant in sand mixed with humus grew better than the one in plain sand.)
- How could the boy have improved his experiment? (He should do this with *several* bean seeds in sand and *several* in sand mixed with humus.)

B. LEARNING MORE ABOUT PLANTS

The following are additional activities. They will help pupils apply their understandings of the needs of plants in general to their learnings about the plants in their school, home, and neighborhood.

1. Plant an herb or edible vegetable (e.g. parsley or radish) that can grow in a window box. When the miniature crop is ready, harvest, wash, and eat it.
2. Look for ivy on the walls of buildings. Find the stem that goes into the ground. Look for the tendrils that anchor ivy to the wall. How do they do this? Compare ivy with other climbing plants.
3. Observe aquatic plants to find out how they are able to live entirely under water.
4. Raise plants like philodendron, Chinese evergreen, English ivy, tradescantia, which can grow with their stems and roots in water.
5. Visit a local greenhouse or botanical garden to notice provisions for appropriate humidity, temperature, ventilation, light, water, soil, and drainage.
6. Make attractive labels for the plants in the classroom.
7. Observe the color of grass which has been covered by a board or other object.
8. What is the color of the stem and leaves of a potato which has sprouted in the dark? See how the color changes when the potato is kept in sunlight.
9. Make a desert garden, using cacti and other suitable plants.



10. Make a bottle garden.
11. Stage a class or school plant show.
12. Start a plant "clinic." Diagnose "ailing" plants in the classroom, and other classrooms in the school; "prescribe" treatment, observe for signs of recovery, and return plant with instructions for care.

C. THE NEEDS OF ANIMALS

Background for the Teacher

The animal kingdom includes over a million kinds of animals. They range from microscopic one-celled animals (protozoa) to those made of billions of cells. Yet each species carries on the same basic life processes.

All can reproduce their kind; all can respond to stimuli; all can secure food and obtain energy from it, or transform it into living material for growth; all can dispose of their wastes.

Animals are amazingly successful in reproducing their kind. The female oyster produces nine million eggs each season. The female housefly lays up to six hundred eggs at a time. Mammals, such as deer, elephants and squirrels have smaller numbers of offspring. What they lack in numbers they make up in parental care, in intelligence, and in other characteristics which insure their survival.

Animals are sensitive; they respond to outside forces or stimuli. The frog responds to low temperature by slowing down its body activities in hibernation. A flying duck hawk unhesitatingly plummets down at speeds up to 80 miles an hour to capture its prey.

All animals are able to secure food, but the methods used vary greatly. Once obtained, however, the food is used as fuel for their "engines." In a series of complex chemical changes, the energy stored in food molecules is slowly released. This use of food for energy is often compared to the burning of a fire. In both processes, complex molecules are broken down into simple ones with a release of energy. But unlike a fire, the "burning" in animals takes place slowly at low temperatures and the energy released is used for the many processes of life such as movement and transmission of nerve impulses.

One characteristic of an animal is growth. A human baby that weighs, at birth, about seven pounds matures into a grownup weighing 140 pounds or more. Where does this increase come from? Part of the food taken in by the animal is converted into the living substance called protoplasm. Growth, then, means an increase in this complex chemical material of life.

Oxygen is required by animals for the release of energy from food, necessary for all life activity. Some, such as fish, lobsters, and clams extract the oxygen from the air that is dissolved in the water in which they live. (You can see this air if you allow a glass of cold water to

stand in a warm room for a few hours. Bubbles of air form on the sides of the glass.) The animals just mentioned are equipped with special devices, such as gills, to extract the dissolved oxygen from the water. Warm-blooded animals, such as birds and mammals, require the most oxygen since they must produce heat constantly to maintain their normal body temperature.

An animal must continually rid itself of its wastes. Simple animals, such as the one-celled protozoa that live in the water, simply expel their bodies' liquid wastes into the water through their covering membranes. In complex animals, the kidneys, skin and lungs (or gills) assume the vital job of getting rid of such liquid and gaseous wastes as salts, urea, and carbon dioxide. Solid wastes are discharged from an opening at the end of the food tube.

Approaches and Learnings for the Child

Even in a large city there are many animals that can be found by alert observers. To launch this topic the teacher may invite the children to list all the animals they can find in their neighborhood. The list becomes longer when the children realize that the animal world includes such forms of life as fish, worms, insects, birds, snails and snakes, as well as mammals. Discussion will disclose the possible places to explore: homes, pet shops, zoos, markets where live poultry or fish are sold, trees, lawns, under rocks, in water, air, soil, and on plants. In this study of the needs of animals, children are also encouraged to observe their cats, dogs, birds, fish or turtles, to learn how these pets eat, move, rest, breathe and protect themselves.

From the activities suggested, children learn the following.

Animals are alike in that they need food, water, air, and shelter.

Each kind of animal feeds, moves, and protects itself in its own way.

1. What do animals in a zoo need in order to live?

If possible, on a trip to the zoo, arrange to be there when the animals are being fed. Have children visit a number of cages and observe carefully what the keeper puts in each cage and where he puts it. Have the children note the different kinds of "houses" in which animals live.

- *Animals need food and water in order to live.*
- *Different animals require different kinds and amounts of food.*
- *Animals need shelter.*
- *Some animals need special kinds of shelter.*

2. What care are animals given in our homes and in a pet shop?

Take a class on a trip to a neighborhood pet shop. If possible, arrange in advance with the shopkeeper for a guided tour. Have children observe carefully how the different animals eat, drink, move about and sleep.

Encourage children to ask questions. Note the movements of the animals as they breathe. Obtain the approval of the owner for a child to hold his hand close to the nose of a tame puppy to feel its breath. Ask children how many have pets at home similar to the ones they found in the pet shop. How do they care for them at home?

- *Animals need air in order to live.*
- *Animals feed and move in different ways.*

3. What do fish in our aquarium need in order to live?

Have the children help in setting up an aquarium. Encourage them to observe, to ask, and to answer such questions as: Can a fish remain in one spot? (Yes.) Do the fins always move? (Some do.) How many fins are there? (Seven.) What is the tail used for? (Propelling the fish.)

Where are the eyes placed? (Usually on the side of the head.) Does a fish ever close its eyes? (No.) What covering is on most of its body? (Scales.) Does the fish eat its food from the top of the water, from the bottom or in the middle? (Depends on the fish.) What does it eat? (Depends on the fish.) What is the temperature of the water in the aquarium? (Test with a thermometer.) What does the fish do with its mouth? (Opens and closes it constantly to take in water.) Can you see something that opens and closes on the side of a fish's head? (The gill covering moves as water flows out of the side of the fish's head.)

After watching the mouth and gill cover movements children may be able to infer that a fish takes in water through the mouth, passes it over its gills and out through the openings on the side of the head. The water has air in it. Part of this air (the oxygen in it) is taken in by the fish's gills and then passes into its blood stream. To show that there is air in water, let a glass of tap water stand for a while. Observe the air bubbles clinging to the side of the glass.

Visit the Aquarium, a pond in the park, a river or the seashore.

Visit a fish market to observe where live fish are kept.

- *A fish moves forward by using its tail.*
- *The body of a fish is covered with scales.*
- *The eyes of a fish help it to see well on both sides.*
- *The fish's mouth and gill covers move when it breathes.*

- *A fish gets air from the water.*
- *Different kinds of fish eat different kinds of food.*

4. What birds feed on our lawn or at our bird-feeding station?

Many easily recognized birds can be seen in New York City. (See page 137, *Science: Grades K-2*.) In the third grade, closer observation of the most common city birds should be encouraged. This may stimulate children to find out what birds need in order to live. To obtain a closer view of birds, place a bird-feeding station on a pole or on a window sill of a lower floor of the school or home. (See page 138, *Science: Grades K-2* for a list of foods.)

Take a bird walk (around the block, to a lawn, to a park) or observe from the classroom windows. Some questions children may try to answer are: What is that bird doing? (Feeding, flying, perching, hopping, singing, bathing.) How close can you get to a bird before it flies away? What does it do to prepare for a "take-off"? What does it do with its wings and tail as it "comes in for a landing"? Does it flap its wings all the time when it flies? Does it walk or hop? Does it have the same color all over? In a group of birds that you see, are all of the same kind? Can you tell the male from the female?

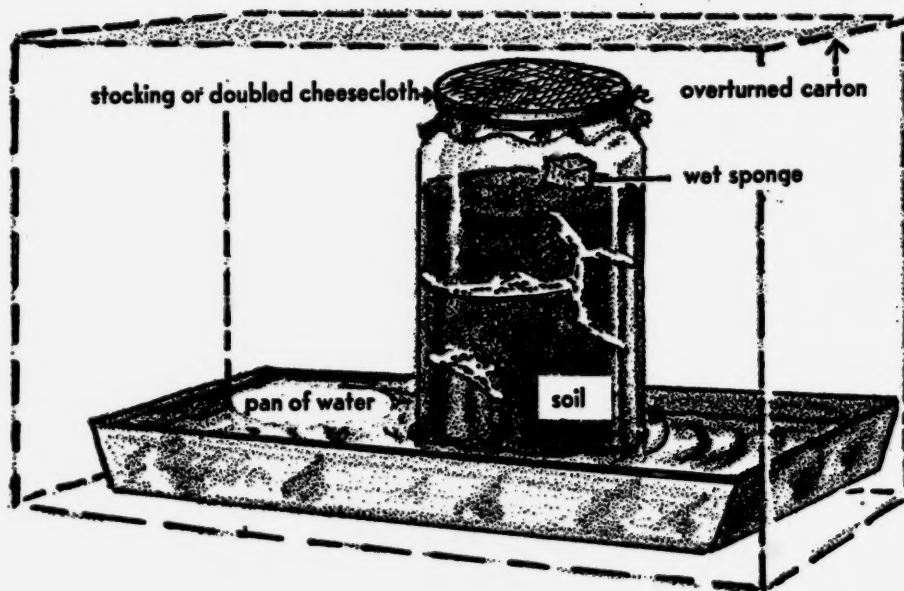
Keep a record of the kinds of birds seen in the neighborhood at different seasons. As each new bird is seen, add its picture to a chart.

- *Birds live where they can find food, water, and shelter.*
- *Some birds can be seen all through the year.*
- *Some birds migrate.*

5. How can we watch ants in our classroom?

Place earth dug up from an ant hill into a glass jar. Cut a small piece of sponge into a one inch cube, moisten it and place it in the jar. Cover the jar tightly with a piece of fine cheesecloth (double thickness), nylon stocking, or paper which is punched with pin holes. Put the jar into a shallow basin of water to cut off the escape route of the more adventurous ants. Keep the jar covered with a dark cloth or black construction paper which can be easily removed to view the ants at work. Every day put two drops of sugar water on the surface of the earth. Try also tiny bits of apple, and bread crumbs. Remove food which remains after 15 minutes. Keep the nest moist, but not too wet.

Why do ants build tunnels? What do they eat? What kinds of things do they carry? How do their loads compare with the size of the ants?



We can easily observe ants in the classroom.

- *Ants need water, food, and shelter.*
- *Ants make their homes in dark places.*
- *Ants eat many kinds of foods.*
- *Ants are strong for their size.*

EVALUATIVE ACTIVITIES

1. Do children evidence more interest in animals by visiting zoos with their families; by reporting on animals seen in the neighborhood; by obtaining and caring for pets; by showing greater concern for the care of animals; by reading books about animals?
2. Are the following true or false? If your answer is "True," explain why it is true. If it is "False," then what is the true answer?
 - a. Birds flap their wings all the time that they are in the air. (False. They often glide in the air.)
 - b. In most birds the female is brighter than the male. (False. The male is usually more colorful.)
 - c. A bird may fan (spread) its tail when making a fast stop. (True. The spread tail hits the air and slows the bird up.)
 - d. All birds fly south in the winter. (False. Some birds stay here all year long.)
 - e. When a robin picks up a bit of string, it uses it for food. (False. It uses it for building its nest.)

3. The fish in a class aquarium did not seem to be doing very well. One fish died, the other four were inactive and came to the top frequently to gulp air. The water seemed murky. What might the trouble be? How could we improve the situation? (The following are some possible answers. *There may be many others of merit*).

What might be the trouble	How we can help
A. There are too many fish in the aquarium. (The rule is "one inch of fish to a gallon of water.")	A. Reduce the number of fish or get a larger aquarium.
B. The fish have been overfed and some of the extra food is rotting.	B. Reduce the amount of food.
C. The plants in the aquarium do not get enough light. As a result they do not make enough oxygen.	C. If possible, place aquarium where it will get more light.

D. LEARNING MORE ABOUT ANIMALS

From the previous activities, children learned of the needs of some animals. They may extend their knowledge by observing or caring for animals included in the activities listed below. Keeping animals in a classroom is an opportunity for teaching conservation. Children will form attitudes from what is practiced in the classroom, rather than from what is preached. The following guidelines may be useful in this connection.

Animals should be given a home which simulates as far as possible their natural environment, by use of appropriate twigs, soil, moisture, food, air and space.

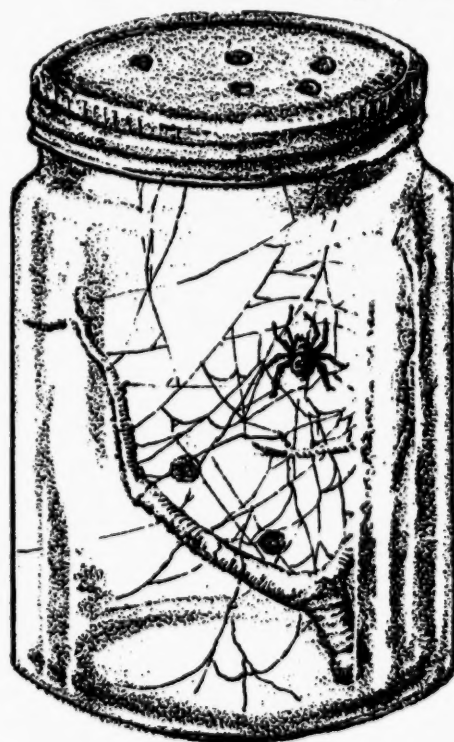
If feasible, animals taken from outdoors should be returned there when the study is over.

Animals are to be regarded as *individual*, living creatures, and not as playthings.

1. Watch an ant to find out what it is doing.
2. Find a grasshopper and try to measure how far it can jump.
3. Visit a zoo during feeding time to see the wide variety of foods used.
4. Bring in fish scales from different kinds of fish to examine with a magnifying glass. A local fish store will furnish fish scales. Each ring on a scale indicates a year's growth.

GRADE THREE

5. Place a cricket in a jar partly filled with earth. The cover should be pierced to admit air. A peeled piece of apple will provide food.
6. Make a record of what your pet eats and drinks during one day.
7. How do animals in your neighborhood live in the winter?
8. Examine a fish skeleton brought from home. Discuss how this bony framework provides support for the fish.
9. Hold a class pet show. See illustration on page 172, *Science: Grades K-2*.
10. Keep some small snails in a fish tank. When it is on the side of the tank, examine a snail with a magnifying glass. Notice its rasping tongue and the movement of its foot. Look for snail eggs and young.
11. Look at a large feather through a magnifying glass. Try to find out how it can "zip" and "unzip."
12. Have a child secure parents permission to bring in his parakeet and report on its food and other needs. (Do not allow the bird to be taken out the cage.)
13. Ask children to name and describe the kinds of dogs they own. Make a labelled display of snapshots of these dogs.



House spider and egg cases.

14. Look for spider webs. Are any insects trapped in the web? Can you find the spider? If the spider is placed in a closed jar with some twigs, will it spin a web? Will it lay eggs? It will be necessary to add food (usually living insects) and a few drops of water if the spider is kept for any length of time.
5. Find a few cocoons to put in a jar. See what emerges. (See page 174, *Science: Grades K-2*.)
6. Look under stones and boards in vacant lots to see what lives there.
7. During warm weather, dig up some earth. Spread the soil out on a sheet of newspaper. See if there are any animals in it. Try to identify them.

BASIC SUPPLY LIST FOR THE NEEDS OF PLANTS AND ANIMALS

*Indicates quantity for entire class; other quantities
specified are for each group of 4 children.

E-1: Science Supply List

- | | |
|---------------------------|--------------------------|
| *1 Thermometer | 2 sheets Cellophane |
| *10 lbs. Gravel | 1 Polystyrene Tray |
| *10 lbs. Soil | *1 Aquarium |
| *Aluminum Foil | *1 Aquarium Cleaner |
| 4—4" Flower Pots | *1 Aquarium Dip Tube |
| 2 Saucers for Flower Pots | *1 Aquarium Feeding Ring |
| 1 Sponge | 7 Pot Labels |

Not on current E-1 List (Will appear on future lists)

- | | | |
|--------------------------|----------------------------|--------------|
| *1 Sprinkling Can | Seeds—1 pk. each of zinnia | kidney beans |
| *1 small pkg. Fertilizer | sunflower | parsley |
| | lima beans | radish |

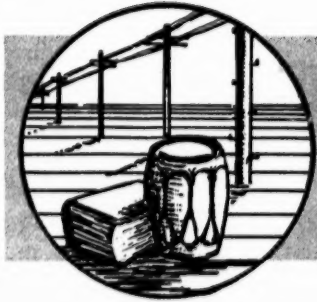
G-1: General Supply List

- 1 pk. Cheesecloth
- 6 large sheets Oatmeal
- 6 small sheets colored Construction Paper
- 2 small sheets black Construction Paper
- 1 jar Paste
- 1 pkg. Clay
- Paper
- 4 small Blotters
- 4 Dowel Sticks

*Miscellaneous:

- | | | |
|--------------------|----------------------------|---------------------|
| 2 paper Bags | 3 clear plastic Containers | **tradesantia |
| 1 pk. Bird Food | 1 celery stalk | *narcissus |
| 1 pk. Fish Food | 12 paper towels | *onion bulbs |
| 1 Bird Feeder | 2 nylon stockings | **pothos |
| 1 apple | 1 pk. vegetable coloring | **begonia |
| 1 pk. bread crumbs | 2 water snails | **philodendron |
| 1 cup sugar | **ivy | **Chinese evergreen |
| 1 yd. black cloth | **coleus | **nephthytis |
| 1 pk. pebbles | **geranium | **bryophyllum |

**May be purchased from the *School Garden Association of New York.*



How Sounds Are Made

A. SOUND AND VIBRATION

Background for the Teacher

Every sound can be traced to something that moves. A drumhead moves when it is banged; our vocal cords move when we speak; a bell moves when it is struck. This movement, characteristic of sound, is a back-and-forth motion called vibration.

When we pluck a guitar string it vibrates. This back-and-forth motion disturbs the air around the string. The molecules of air also are made to vibrate. Each time this happens a wave is started in the air and eventually reaches our eardrums. Nerve endings stimulated by the vibrations carry messages to our brain, which interprets these stimuli as sound. (The transmission of sound is discussed more fully in the *Background for the Teacher*, Grade 4, Topic A, page 206.)

Because vibrations are produced in many different ways and with many different materials, the sound waves produced are different. This is why we hear different kinds of sounds. Sounds may be pleasant or unpleasant, loud or soft, high or low, musical or discordant.

Approaches and Learnings for the Child

By observing common musical toys and by conducting simple experiments, children find out that sounds originate from vibrating objects. They discover that a number of methods can be used to make objects vibrate. From the activities, children learn the following.

Musical sounds can be made by plucking, striking, blowing, and rubbing.

When a sound is produced, something is vibrating.

Vibration is the back-and-forth movement of an object.

When the vibration stops, the sound stops.

Vibrations often can be felt or seen.

1. Can we "feel" or "see" sound?

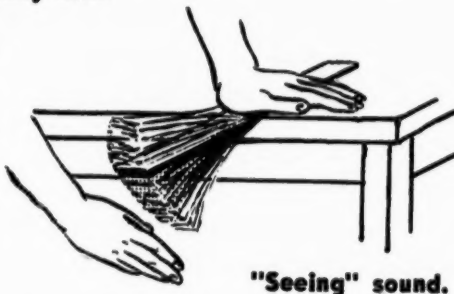
The purpose of the following activities is to focus the childrens' attention on some ways, other than hearing, of sensing the vibrations which accompany sounds.

To vibrate means to move back and forth. Children use words like shake, shiver, or jitter to describe this motion. The word *vibration* should be introduced by the teacher, if it is not yet in the children's vocabulary.

Ask the children to suggest ways of "feeling" or "seeing" sound. Some activities which show the relation between sound and vibration follow:

- a. Have the children touch a radio cabinet or a piano while it is being played. Ask them to describe what they feel.

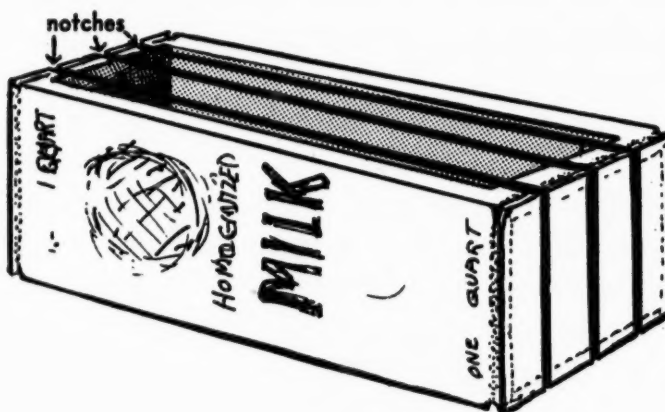
- b. Make a thin wooden ruler or a plastic ruler vibrate, as shown. Ask the children to describe what they see, hear, and feel. Also try this with other objects such as a nail file, tongue depressor, and dowel stick.



- c. Strike a triangle with a tapper. Ask a child to touch it gently with his fingertips. Strike the triangle again while the child is grasping it firmly. Is there a tingling the second time? What happens? Why? (Stopping the vibration stops the sound.)



"Feeling" sound.



A milk-carton, rubber-band guitar.

- d. Stretch a rubber band around a milk carton. Pluck the band. Ask the children to report what they see, hear, and feel. Also try stretching the rubber band around a drawer, chairback, cigar box, cup, or plate.

GRADE THREE



"It looks blurry."

- e. Cut a rubber band apart. Have one child stretch it tightly, using both hands. Have another child pluck it. Children discuss the movement of the rubber band, and the sounds heard. They may note the visible blur caused by the vibration of the rubber band.



"It makes a nice sound."

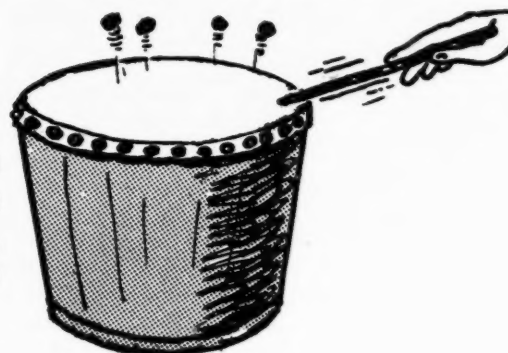
- f. Have a child strike a fork (silver is best), and listen to the sound caused by the resulting vibration.



"It tickles."

- g. Have each child fold a piece of paper, about 3 x 6 inches. Hold as shown and blow into the fold between the fingers. Ask the pupils to tell what they feel when the paper gives off sound.

- h. Beat a drum. Have the children feel the sides of the drum with their fingertips. While drumming, sprinkle sand or any dry cereal on the drumhead. What happens?



"They jiggle."

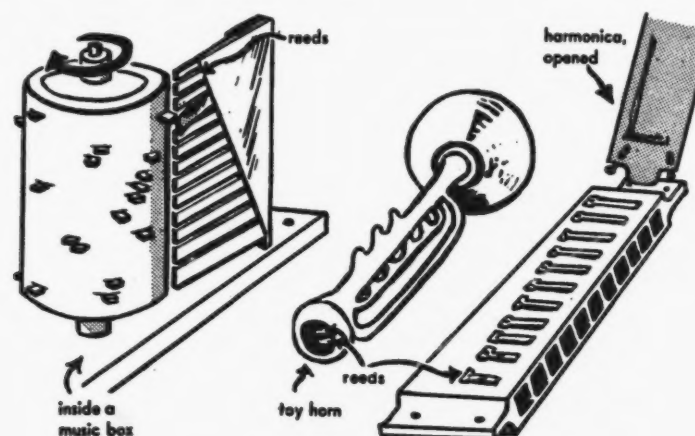
- i. Have each youngster hold his fingers against his throat while talking or humming. Ask the children what they feel.

- *Objects vibrate while they are sounding.*
- *Vibrations often can be felt or seen.*
- *When the vibration stops, the sound stops.*

2. How do musical toys work?

Children will be interested in finding out how musical toys work. They will find that sounds are produced in a number of ways: by plucking, by striking, by blowing, and by rubbing. In some toy instruments the force needed to cause vibration is supplied by winding a spring, by pulling the toy, or by whirling the toy.

Children will look for the part of the toy responsible for the sound: the part which vibrates. Some vibrators which are found in musical toys are: reeds, drumheads, strings, bars, tubes, air columns, balls.



Reeds vibrate in these musical toys.

The following chart describes some musical toys. Remember that not all toy instruments operate in the same way as the instruments which they represent. Gather as many musical toys as possible.

TOY	PART THAT VIBRATES	METHOD OF PRODUCING SOUND
Harmonica	Metal reeds of varying length. If top of the harmonica is removed, (see illustration opposite), reeds can be examined. The long ones produce the low tones, the short ones, the high tones.	Blowing. The reeds are attached so that some of them vibrate when air is blown in and some when air is drawn out.
Accordion	Metal reeds of varying length. Each key controls a valve, which allows air to blow across a particular reed.	Blowing. The squeezing and the extending of the bellows causes air to be forced across the reeds, just as in the harmonica.
Horn Clarinet Saxophone Trumpet Cornet Trombone	Reeds. (In real trumpets, cornets and trombones, the player's lips serve as reeds.)	Blowing.

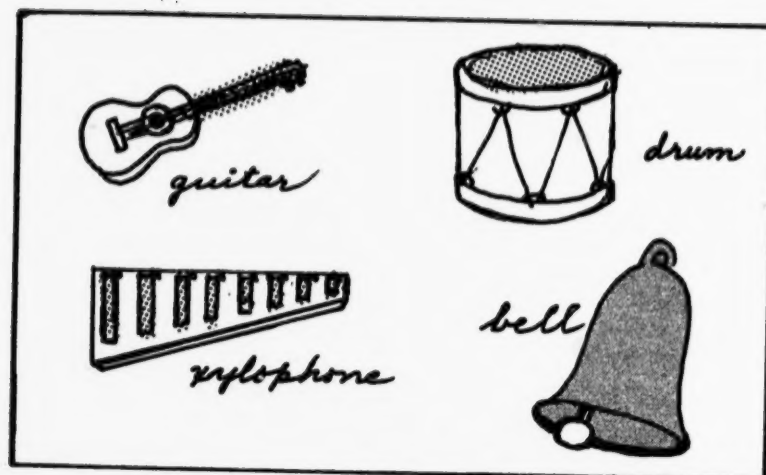
GRADE THREE

TOY	PART THAT VIBRATES	METHOD OF PRODUCING SOUND
Musical Top	Metal reeds.	Blowing. The spinning motion of the top causes air to blow through openings in the top.
Piano	Metal bar.	Striking.
Xylophone	Metal bar.	Striking.
Music Box	Metal reeds of different length attached to a bar. See illustration on page 78.	Plucking. A moving belt with projecting fingers or flaps plucks one or more of the reeds at the same time.
"Humming Lariat"	Rubber band reed. Different humming sounds can be made by adjusting (stretching or loosening) the rubber band.	Blowing. Whirling the lariat through the air makes the rubber band vibrate.
Cowbell	Bell.	Striking. The clapper hits the bell.
Whistle	Air column in whistle. In a whistle containing a ball, the ball, by moving about, varies the length of the air column, producing a warbling sound.	Blowing.
Drum	Drumhead.	Striking with sticks or hands.
Kazoo	A membrane of thin paper.	Humming into the toy.
Violin	Strings.	Bowing the string.

- In toys, musical sounds are made by plucking, striking, blowing, or rubbing.
- The part of the toy which produces the sound moves back and forth rapidly: that is it vibrates.
- The vibrating part may be a reed, a drumhead, a string, a bar, a tube, a ball, a paper membrane, or a column of air.

EVALUATIVE ACTIVITIES

- Can you tell why
 - a door bell will not ring if you hold the clapper tightly? (You prevent the clapper from striking the bell. Therefore, no vibrations will be produced.)
 - you hear a sound when you pluck a rubber band? (The rubber band vibrates, the air vibrates, and then the vibration reaches your ear.)
 - you must strike a triangle to have it make a sound? (You must make the triangle vibrate.)
 - the drummer put his hand on top of the drum when he wanted to stop the sound? (His hand stopped the drum from vibrating.)



2. Color the part of each instrument that you must make vibrate or move so it will make sound. (Areas to be colored by the children are shaded in illustration. Present children with *unshaded* outlines.)
3. What must you do to each of the following instruments to make sound? Select the right word (pluck, strike, blow, rub) for each instrument.

violin (rub, pluck)	banjo (pluck)	harp (pluck)
drum (strike)	xylophone (strike)	trombone (blow)
flute (blow)	triangle (strike)	harmonica (blow)
4. Without using your ears, how could you tell that
 - a. a drum was making sound? (Feel vibrations; place small objects on drum-head and see if they move.)
 - b. a rubber band guitar is making sound? (See the rubber band moving; feel vibrations.)
 - c. a radio is playing? (Feel the vibrations when you touch the radio.)
 - d. someone is humming? (Feel vibrations when you touch his throat or chest.)

B. HIGH TONES AND LOW TONES

Background for the Teacher

When a guitar string is plucked, it vibrates at a constant rate—at so many vibrations per second. As a consequence, a corresponding number of sound waves are started in the air each second. The number of vibrations (waves) produced per second is called frequency. The human ear can hear sounds with a frequency that ranges between approximately 20 and 20,000 vibrations per second.

If a guitar string is tightened and then plucked, it vibrates more rapidly than before. The more vibrations it produces in a second, the higher is

the pitch. If a guitar string is loosened and then plucked, it vibrates more slowly. The fewer vibrations it produces in a second, the lower is the pitch. Pitch, then, depends on the frequency of vibration.

The pitch of a musical string is determined not only by its tightness but also by its length and weight. (The weight depends on the thickness and the material used.) A shorter string produces a sound of higher pitch than a longer one; and a lighter string produces a sound of higher pitch than a heavier one.

In wind instruments, the pitch is determined mainly by the length of the column of vibrating air. A shorter air column produces a higher pitched sound than a longer air column.

Approaches and Learnings for the Child

In this grade, a series of experiences are suggested which help the children understand the relationship of pitch to the size of the object producing the sound. Children can discover this knowledge by collecting, manipulating, constructing, and experimenting with sound-making objects. For example, when they strike two objects similar in kind (such as two jars), the smaller one generally produces a higher-pitched sound than the larger one.

From the activities suggested, children learn the following.

Higher tones are usually produced by the vibration of small objects; lower tones by the vibration of large objects.

In stringed instruments, different tones are produced by using strings of different length or of different tightness.

In wind instruments, different tones are produced by using air columns of different lengths.

1. What kind of tone is it?

The purpose of this activity is to focus the children's attention on distinguishing between a higher tone and a lower tone. The materials used in this activity are placed on the teacher's desk or demonstration table, but *shielded from the view of the children*. A desk blotter or large sheet of oaktag may be used as a shield.

- a. Strike the longest bar of a xylophone, then strike its shortest bar. Have children discuss the tone heard in each case. Repeat this activity with other pairs until the children are able to recognize the difference between the higher tone and the lower tone. Children should have as

much practice as necessary until they can discriminate between higher and lower tones.

- b. Obtain a set of Melody Bells. Shake the bell that has the highest tone, and then the bell that has the lowest one (one bell at a time). Repeat as often as necessary to reinforce the children's ability to distinguish between a lower and a higher tone.
 - c. Repeat activities "a" and "b" using a string instrument, such as a toy violin, toy guitar, a home-made guitar, or a real string instrument.
- *Some tones are higher than others.*

2. What makes a higher tone or a lower tone?

Use the same materials as in Problem 1. Demonstrate these in full view of the children. (Remove the shield.)

- a. Distribute a number of xylophones (one xylophone for a group of no more than four children). Ask a child to strike the longest bar, and then the shortest bar. Have children discuss the difference in tone of the sounds they hear. Guide them to understand that a longer bar produces a lower tone; a shorter bar produces a higher tone.
 - b. Repeat Activity 2a, using Melody Bells, to reinforce the children's understanding of higher and lower tones. Children examine the real sounding bell which is hidden by the outside plastic cover.
 - c. Repeat Activity 2a, using a string instrument. Children discover that a longer string produces a lower tone and a shorter string produces a higher tone.
- *In a xylophone, the longest bar makes the lowest tone; the shortest bar makes the highest tone.*
 - *In Melody Bells, the largest metal bell makes the lowest tone; the smallest bell makes the highest tone.*
 - *In a stringed instrument, the longest string makes the lowest tone; the shortest string makes the highest tone.*
 - *Higher tones are usually produced by the vibration of smaller objects.*
 - *Lower tones are usually produced by the vibration of larger objects.*

3. What other objects can we use to make higher tones and lower tones?

The experiences of children with musical instruments, real or toy, may

GRADE THREE



Making high tones and low tones.

lead to this investigation. Secure pairs of objects (suggested by the children) such as:

pint fruit jar and quart fruit jar	small medicine bottle and large medicine bottle	small pitcher and large pitcher	
small bell and large bell	small whistle and large whistle	small drum and large drum	small dish and large dish

Children tap the smaller object and then the corresponding larger one with a stick or pencil, and compare the tones produced.

A committee of children may be interested in making a set of flower pot chimes. Hang the chimes by twine attached to buttons or sticks which



Flower-pot chimes.

are large enough not to slip through the drainage holes in the pots. A small stick or ruler may be used to tap the flower pots.

- *Tapping an object makes it produce sound.*
- *When tapped, larger objects usually make lower tones, smaller objects higher sounds.*

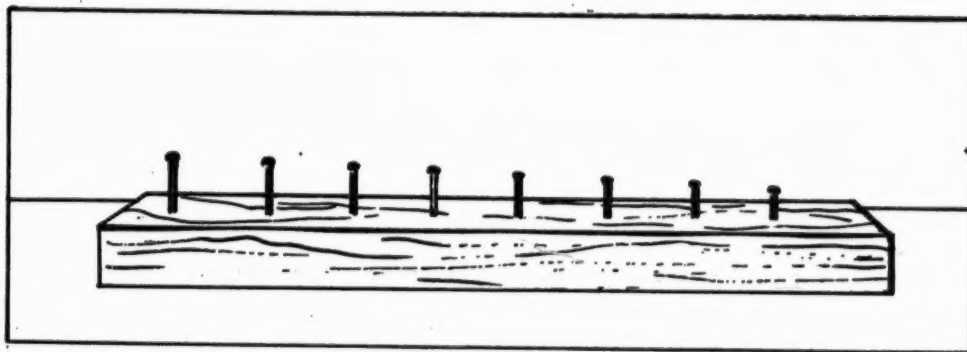
4. How can we make a xylophone, using nails?

Drive several nails of the same size into a board, each one hammered in a little more deeply. 1½" to 2" brads are a good size. Tap the nails with a large nail to make them vibrate. Which nail, when tapped, makes the lowest sound? Which nail, when tapped, makes the highest sound?

Children experiment with this nail xylophone by varying the distance the nails are driven into the board. Try using nails of different thickness or length to produce sounds.

Can you play a tune on this instrument?

- *When tapped, a longer nail produces a lower tone than a shorter nail.*
- *We can make many tones from low to high by using nail lengths from long to short.*



A xylophone made with nails.

5. How can we make bottle-whistles?

Have children recall hearing the sound of a train whistle or boat whistle, and of toy wind instruments (organs, fifes, horns, or harmonicas).

Secure about six clean, empty, glass bottles of various sizes. Plastic bottles may be substituted if children are asked to bring bottles from home. Plastic bottles, due to their resilient nature, will make sounds if one blows very gently across their mouths. If no sound is produced, from either glass or plastic, suggest that the child blow down as well as across.



The biggest bottle makes the lowest tone.

Ask one child to blow softly across the smallest bottle. Ask a second child to do the same with the next bottle. Continue until all bottles are supplied with musicians. The children generalize that the larger the bottle, the lower the tone. Ask: In which bottles do we have the most air? (The largest bottles.) In which bottles do we have the least amount of air? (The smallest bottles.)

Another discovery may be that the combined sounds of some bottles are pleasant or unpleasant. Discuss with children how musical instruments such as the recorder, pan-pipes, and organ can produce tones of different pitch.

- *Blowing into or across a bottle makes it whistle.*
- *Bigger bottles usually make lower sounds; smaller bottles higher sounds.*
- *When we blow into a number of bottles, the one with the most air in it makes the lowest sound; the one with the least, the highest.*

6. How can we make a milk-straw horn?

Distribute a milk straw to each child. Partly flatten about one-half inch of one end and cut to shape it as shown in the illustration. Blow into it.

While blowing, use a pair of scissors to snip off pieces of the other end of the straw about one-half inch at a time. The pitch of the horn will rise as you shorten the tube.

- *The longer the straw, the lower the tone; the shorter the straw, the higher the tone.*



7. How does a recorder make music?

Secure as many recorders as possible. Have children determine how sounds are made with the instrument. Children discover that tones can be produced by covering and uncovering the holes of the recorder. When all the holes are covered, the air in the entire tube vibrates, just as in a bottle, to produce a note of a certain pitch. If the player removes his finger from the hole farthest from him, he produces a note of slightly higher pitch. This happens because the column of vibrating air becomes shorter, extending from the mouthpiece to the uncovered hole.

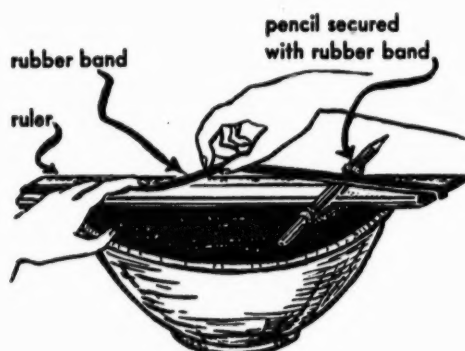
Other instruments which are played in this way are fifes, flutes, clarinets, saxophones, oboes, English horns and basoons.

However, the length of the column of air in a trombone is changed by moving a sliding U-tube.

In some brasses—the cornet, trumpet, tuba, and other horns—the length of the air column is changed by pressing keys. These are valves which open or close sections of the instrument to change the length of the column of air inside. Thus the valves act as the fingers do over the flute-holes.

- *In a wind instrument, a column of air vibrates inside the instrument to produce sound.*
- *The length of this air column can be varied to produce tones of different pitch.*
- *The longer the column of air, the lower the pitch; the shorter the column of air, the higher the pitch.*

8. How can we make a rubber-band guitar?



This guitar, which can be assembled in a few minutes by each child, uses easily available materials. Pluck this to play it, pressing the rubber band to the ruler with the other hand. Children will discover that they can sound different notes by moving the left forefinger along the string, pressing it against the ruler at various points. Some may be able to play simple tunes, such as *Three Blind Mice*.

Discuss with the children why moving the finger in this manner causes tones of varying pitch. They should understand the following:

GRADE THREE

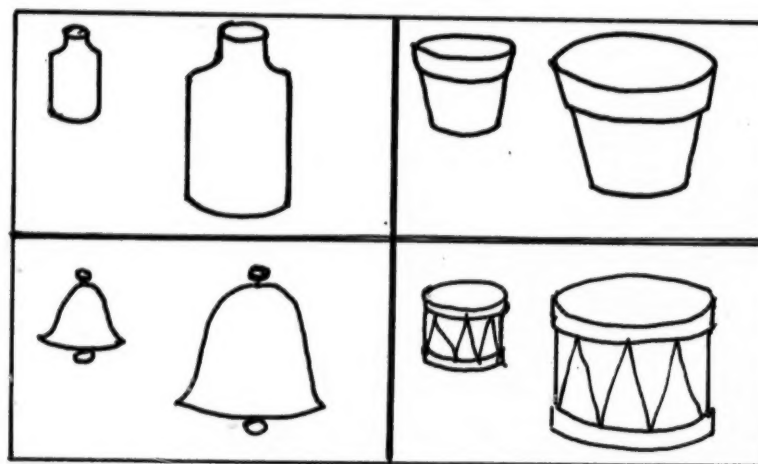
- a. Only the part of the string that is plucked, and is free to vibrate, makes the sound.
- b. This part extends from the place where the string is pressed, to the bridge (the pencil).
- c. The longer this part is, the lower the pitch. The shorter this part is, the higher the pitch.

In the case of stringed instruments, the strings are plucked or bowed (rubbed) and hence made to vibrate.

- *We can make a musical instrument by using a tightly-stretched rubber band.*
- *We can make lower and higher tones by using different lengths of the rubber band.*
- *We play musical instruments like guitars and violins in the same way as the rubber-band guitar—that is, by making different lengths of the strings vibrate.*

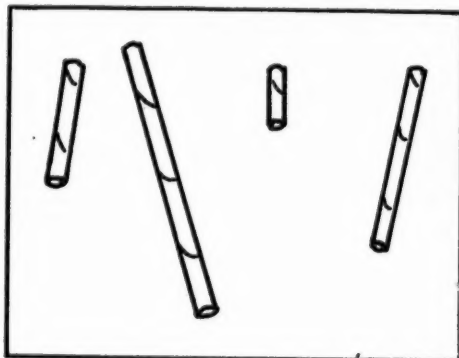
EVALUATIVE ACTIVITIES

1. In each pair of objects pictured below, color the one that can make a higher sound. (The smaller objects should be colored.)

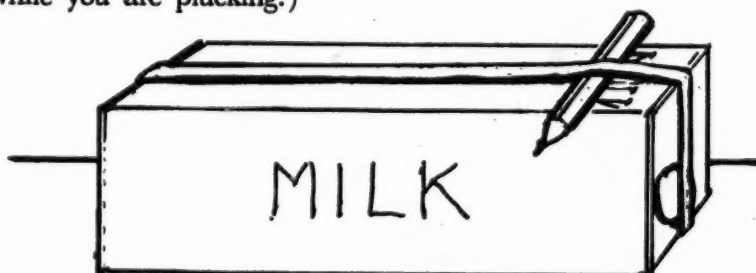


2. Why
 - a. does a violinist place his finger on different parts of the string when he is playing the violin? (To change the pitch. This is done by changing the length of the vibrating part of the string.)
 - b. does a trombone player slide part of his instrument in and out? (This increases and decreases the length of the tube and therefore the length of the vibrating column of air.)

- c. are the strings of a harp of different lengths? (The length of the string is related to the pitch; the shorter the string, the higher the pitch; the longer the string, the lower the pitch.)
 - d. does a guitar player tighten or loosen the strings of his instrument before he begins to play? (To get the right pitch; the tighter the string, the higher the note; the looser the string, the lower the note.)
3. Pictured below are some drinking straws that have been cut to make a musical toy. Write "1" under the straw which will make the lowest note and "4" under the straw with the highest note. (The longest straw is 1 and the shortest straw is 4.)



4. Here is a picture of a milk carton with a rubber band on it. In how many different ways can you make the rubber band produce sounds of different pitch? (Stretch it and pluck; press one finger at different places on the rubber band while you are plucking.)



C. FINDING OUT MORE ABOUT SOUND

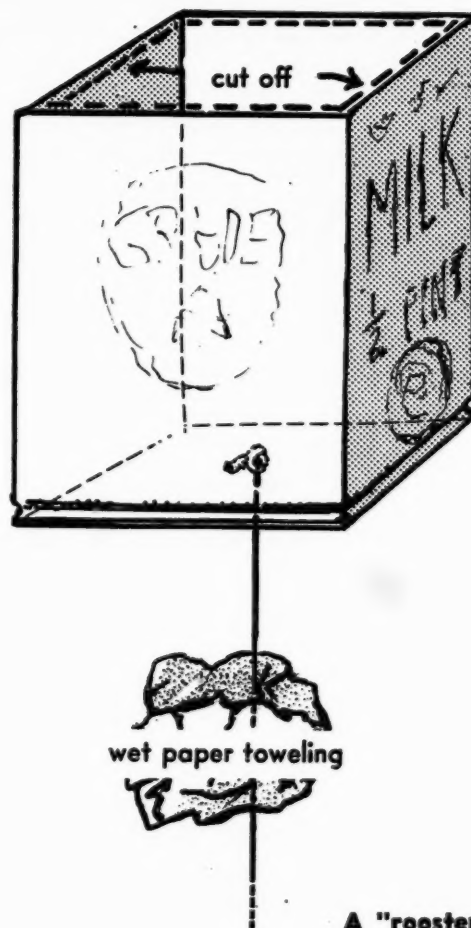
The questions and suggestions proposed below are intended for pupils who are interested in learning more about the science of sound, and who wish to conduct independent investigations to find the answers to some of these questions. A number of the items will also serve as a basis for class discussions.

1. Make a whistle collection.
2. Tell, by tapping the outside of a carton, whether it is empty or full.

GRADE THREE

3. Tap cardboard cartons of different sizes. What difference in pitch do you notice? (The larger cartons usually give a lower pitch.) Try this also with other kinds of wood and cardboard boxes.
4. Bring in a real musical instrument and demonstrate how it works.
5. How do animals such as frogs, katydids, crickets, cicadas, flies, and bees make sounds?
6. Draw a card over the teeth of a comb at different speeds. How does the speed affect the sound? (When the teeth of the comb are plucked slowly with the card, a low pitched sound is made. When the teeth of the comb are plucked rapidly, a high pitched sound is made. In the first instance, the card vibrates slowly; in the second, the card vibrates rapidly.)

Bibliography, has suggestions for making sound effects.



7. Make a "rooster crower." Cut off the top of a one-half pint milk carton. Rinse carton with cold water. Punch a small hole in the center of the bottom, put a string through hole and knot it. Crumple and wet a small piece of paper toweling. Hold the carton in one hand, draw the wet paper down the taut string as shown. You will hear an unusual sound. By varying the amount of squeezing on the wet paper as you draw it down the string, you can make it sound like a rooster crowing "cock-a-doodle-do."

8. Try making sound effects. For example, crumple pieces of cellophane to simulate the sound of an egg frying. *The Magic of Sound*, listed in the Bibliography, has suggestions for making sound effects.



9. Make a horn, as shown in the illustration. Hum into it, as into a kazoo.

BASIC SUPPLY LIST FOR *HOW SOUNDS ARE MADE*

*Indicates quantity for entire class; other quantities
specified are for each group of 4 children.

E-1: Science Supply List

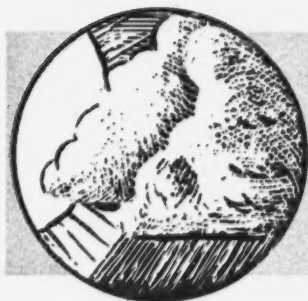
- *1 cup of Sand
- 1 Xylophone
- 1 set Melody Bells
- *5 Flower Pots—various sizes

G-1: General Supply List

- | | |
|---|--|
| <ul style="list-style-type: none"> 1 wooden Ruler—12" 1 Dowel Stick *1 Triangle with Tapper 1 Tongue Depresser 4 Rubber Bands 4 Paper Cups 4 Paper Plates 1pr. Scissors 8 sheets 3x6" Paper *1 desk Blotter | <ul style="list-style-type: none"> *1 Magna Board 1 sheet large Oaktag *10 Pencils *10 Paste Sticks 8 Milk Straws *1 bail of String
(warp, thread, white) 1 Hammer 1 Ruler—18" |
|---|--|

Miscellaneous:

- | | | |
|---|---|---|
| <ul style="list-style-type: none"> *4 Recorders 1 plastic Ruler—12" 1 Nail File 8 Milk Cartons 1 Cigar Box 1 Fork | <ul style="list-style-type: none"> *1 cup of Puffed Rice *assorted Musical Toys *6 glass Bottles of uniform size 1 block of Wood—1" x 2" x 8" Assorted Nails—2" to 3" long 1 large Nail 2 doz. Buttons | <ul style="list-style-type: none"> *assorted, small and large: fruit jars bells medicine bottles dishes pitchers drums |
|---|---|---|



Observing and Measuring Weather Changes

A. TEMPERATURE

Background for the Teacher

To measure temperature, thermometers are used. One type of thermometer contains a liquid, such as alcohol or mercury, which is sensitive to temperature changes. These liquids expand noticeably when heated slightly, and contract when they are cooled. When the liquid expands it can move only upward, through the very narrow bore of the tube, which has a vacuum in the upper portion. The degree-scale used on the common Fahrenheit thermometer is based upon the freezing point (32° .) and boiling point (212°F.) of water.

The weather forecaster uses his thermometer to determine the temperature of the air. All significant readings are made in an enclosure open to the air but shaded from the sun. (Reading a thermometer with the sun beating on it will merely show how effectively the thermometer is absorbing the sun's rays. It will not give any significant temperature reading, nor will it agree with another thermometer of different size or shape held in the same location. It is not intended to be used in sunlight.)

Some thermometers with which the children are familiar, such as the oven thermometer, contain no liquid. The indicators are turned by metal strips designed to coil and uncoil as the temperature changes.

Approaches and Learnings for the Child

The thermometer is a scientific measuring instrument familiar to children both in the home and in the classroom. Children observe the markings on thermometer and learn how to read the scale. They become aware of degrees as units of measurement. They experiment with the thermometer and discover how the fluid in it responds to changes in temperature. They use it to measure the various temperatures in their immediate environment. They observe the thermometer to determine daily fluctuations in temperature and they make a record of their findings.

From the activities suggested, children learn the following.

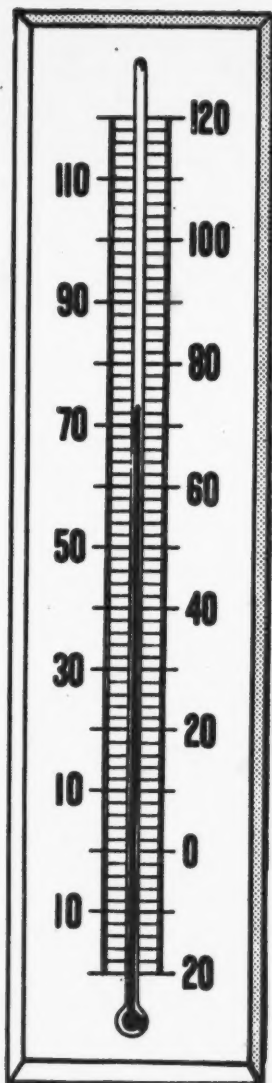
The thermometer measures temperature in degrees.

The liquid in the thermometer expands when the temperature is warmer and contracts when the temperature is cooler.

The temperature changes during the day.

The temperature changes from day to day.

1. What is a thermometer?



Have children examine thermometers obtained from the *E-1 List* (Items #14-0998 or 14-1008). Direct their attention to the long, sealed glass tube and the colored liquid inside the tube. Explain that the liquid with a red color is usually alcohol and that with a silvery color is mercury. Introduce the word *liquid*, and have children name other liquids, such as water, oil, vinegar, and milk.

Have children notice the markings and the numerals along the sides of the thermometer. They will observe that the numbers get larger as they look from the zero mark toward the top. What do these numerals tell us? Before children answer, first ask: What do the numerals on a ruler tell us? What do the numerals on a weighing scale mean?

Guide the children to understand that just as a ruler measures how long something is in inches, and a scale measures how heavy something is in ounces or pounds, a thermometer measures also: it measures how warm something is in units called degrees.

- *A thermometer is usually made of a sealed glass tube with a liquid inside it.*
- *A thermometer has markings which can be used to find out how warm something is in degrees.*

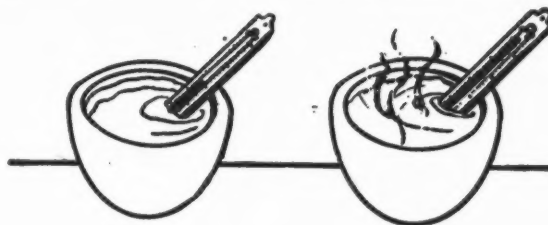
2. How can we make the liquid "line" in a thermometer change its length?

Distribute thermometers (*E-1 List: Item #14-0998*) to children and asked them what they could do to make the liquid in the tube move. They may suggest shaking the thermometer (don't let them do this; it would break the "line" of fluid), laying it on its side, turning it upside down. (The last two suggestions will not work.)

How could we make the liquid move without shaking it or changing its position? Some children may suggest cooling it by putting it on the outside window sill or under running cold water, or warming it by breathing on the bulb or holding the bulb in their hands. Children observe that the line in the tube becomes longer in the latter cases. Encourage them to continue watching the line when they are no longer breathing on the bulb or holding it in their hands. They will notice that the line returns to its original length. Why? (The air around the thermometer is cooler than the air of their breath, and cooler than the skin of their hands.)

Suggest that children repeat these experiences several times to verify their findings. They might make a record of the changes in the length of the thermometer liquid by using paper strips which are cut to match (a) the length of the original line, (b) the length of the line after the thermometer is warmed, and (c) the length of the line after the thermometer is cooled.

How the "Line" Changed					
Breathing on Bulb			Holding Bulb		
before	during	after	before	during	after
					



Encourage further suggestions for ways to change the length of the line. Children may place the thermometer outside on a cold day, put it near a warm radiator, or immerse it in ice water or warm water.

In each case ask them to predict how the line will change before conducting the test. Paper strips may again be used to record the results. Findings may be summarized on a chart such as the one which follows.

<i>What Happened to the Line?</i>		
<i>Became longer when tested</i>	<i>Became shorter when tested</i>	<i>Remained the same when tested</i>
in hot water	in ice water	in water kept
in breath	outdoors	for an hour
in hand	in tap water	in the classroom
on radiator		

This is a good time to introduce the words *expand* and *contract*. When substances (liquid, gas, or solid) are heated they generally expand: that is, they take up more space. When substances are cooled, they contract (shrink): that is, they take up less space. Alcohol and mercury are used in thermometers because they expand and contract considerably with a slight change in temperature.

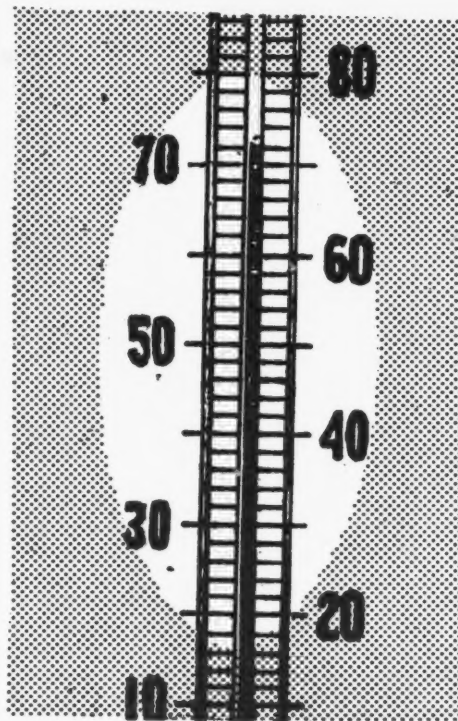
- The liquid "line" in the thermometer becomes longer when it is warmed, and shorter when it is cooled.

3. How is a thermometer used?

Have children recount experiences with thermometers. They may mention the use of clinical thermometers when they were ill; meat or oven thermometers when their mothers cook; and wall thermometers when they want to find out how warm the room is. Guide them to see that, in each case, the thermometer helps us determine how hot something is. More accurately, this is called finding the *temperature* of something.

Distribute thermometers (E-1 List, Item #14-0998) to the children.

Recall the discussion of degree markings in *Problem 1*.



GRADE THREE

Children see where the red line ends on their thermometers and tell you the numerals. Write these on the board. Make it clear to the children that these numerals are read as degrees, and that they are used to show the temperature of something. Lead children to understand that the numerals they have just read measure the temperature of the air around them in the room. If the reading seems to fall between two markings, asks children to estimate the nearest one.

Make sure that the children know how to read the thermometer. Have them each place their thermometer in a container (paper cup) of tap water, and read the temperature again. Record the reading on the blackboard. If widely varying temperatures are reported by some children, check their thermometers. They may be broken or being read incorrectly.

Repeat the experience of *Problem 2*. This time, instead of using strips of paper to record the length of the line in the tube, have children record in degrees the temperature of the material tested. Their investigation could be extended to include such materials as soil in flower pots, milk in containers, the air in their schoolbags and in desks. *Note:* Caution children to hold the thermometer by the stem, not the bulb, for correct readings.

A chart may be made to record the findings of individual children. In each case they might note not only temperature of the item or place tested, but the relationship of that temperature to room temperature.

<i>Temperature of Some Things Around Our Room</i>		
Who Tested It	Place or Material Tested	Its Temperature
Joan and James	Air in room	70 degrees
Maria and Peter	Ice water	40 degrees
Carol and Alex	Tap water	60 degrees
Frances and Bill	Warm water	150 degrees
Annabella and Pasquale	Water that stood for an hour	70 degrees
Alice and Eugene	Air outside	50 degrees
Jenny and Sam	Air over the radiator	95 degrees
Helen and Michel	Milk in container	45 degrees
Rita and Harry	Soil in flower pot	70 degrees

As children have experiences reading temperatures, they become aware of the range of temperatures that can be measured by the kind of thermometer they have been using. (On the *E-1 List*, for example, thermometer 14-0998 reads from 0° to 200° Fahrenheit in 1° divisions.)

Have children examine other thermometers such as clinical, oven, indoor-outdoor, and candy thermometers, to note the range of temperatures indicated on each. Ask them to explain these differences. Discuss, also, the need for thermometers which register temperatures below zero for use in the winter or in the deep-freeze refrigerators. If possible, arrange for children to see thermometers in a supermarket's meat freezer.

- *Temperature is the measure of how warm something is.*
- *Temperature is measured in degrees.*
- *Thermometers are used to measure the temperatures of many things.*
- *Thermometers used for different purposes have different ranges of temperatures.*

4. What is there around us which changes in temperature?

Children may suggest the following examples: warm water left in a pan cools off; cold water allowed to stand in a glass warms up; sometimes we get warmer when we are sick; the outdoor temperature changes during the day; the outdoor temperature changes from day to day.

How can we find out if the temperature really changes? Children will suggest using a thermometer to measure it. Have them make plans for recording the temperature over a period of time. For example, some children may take outdoor-thermometer readings in the shade in the morning, near noon, and in the afternoon for a period of a week or two. Have them record their findings on a calendar or chart.

Other children may experiment with change in the temperature of water. Provide two pans of water. Heat one until warm, but DON'T boil. Put ice

<i>Time</i>	<i>Hot Water</i>	<i>Cold Water</i>
9:30	110°	32°
10:00	100°	38°
10:30	93°	45°
1:00	72°	72°
3:00	72°	72°

GRADE THREE

cubes in the other. Have children take temperature readings of the warm and the cool water, and then take readings at half-hour intervals until the water in both pans comes to room temperature. The resulting chart may resemble the one on page 96.

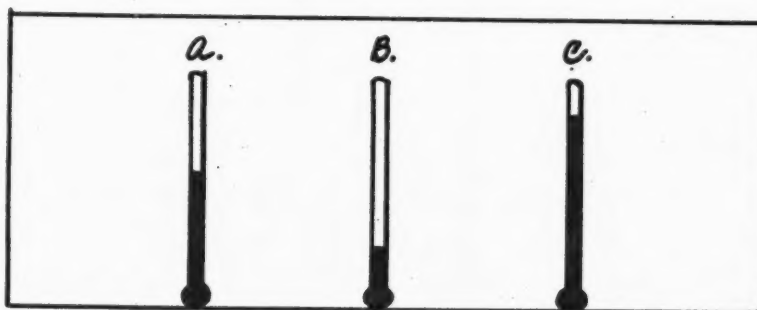
Encourage children to propose, design, and carry through other observations of temperature changes.

- *The temperature around us changes during a day, and from day to day.*
- *We can record the changes in temperature around us.*

EVALUATIVE ACTIVITIES

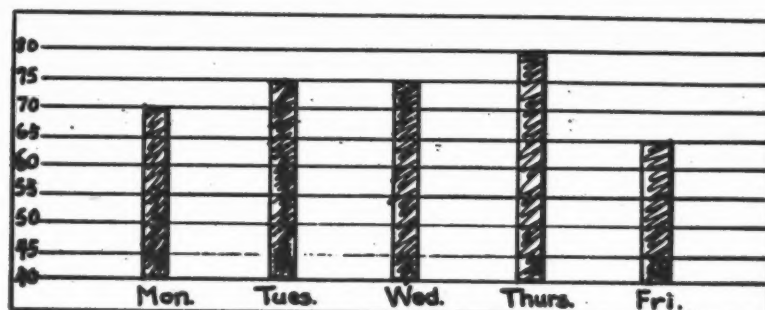
1. Which thermometer would show the hottest day? (C.)

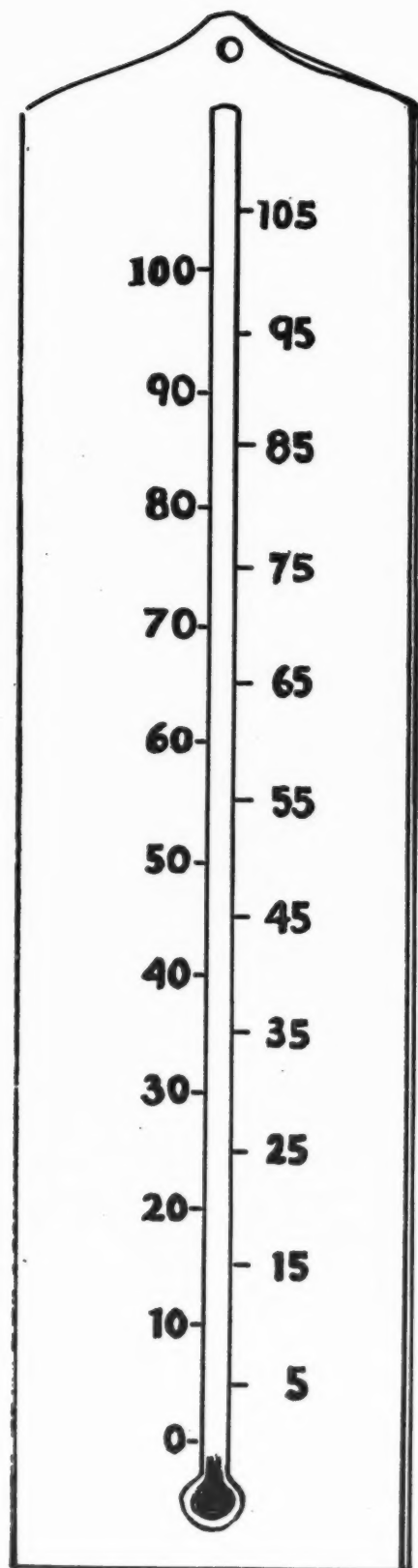
Which thermometer would show the coolest day? (B.)



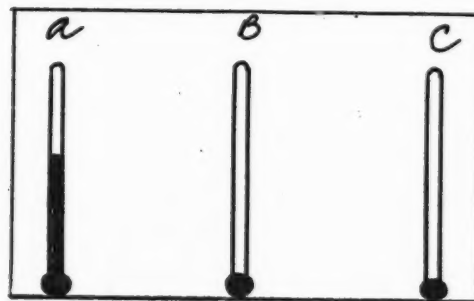
2. Following is a record of the outdoor temperature taken each day for five days.

- Which day had the highest temperature? (Thursday.)
- Which day had the lowest temperature? (Friday.)
- Which days had the same temperature? (Tuesday and Wednesday.)
- What is the difference in the temperature between Thursday and Friday? (15 degrees.)
- What is the difference in temperature between Wednesday and Thursday? (5 degrees.)





3. Give each child three copies of the thermometers as shown below. Thermometer A shows room temperature. Shade thermometer B to show how it would look if it were to be put in cold water. ("Line" should be shorter than that of A.) Shade Thermometer C to show how it would look if it were put in warm water. ("Line" longer than that of B.)



4. Provide children with three illustrations of thermometers as shown on left.
- Shade one thermometer to show a temperature of 50 degrees.
 - Shade another thermometer to show a temperature of 25 degrees.
 - Shade the third thermometer to show a temperature of 72 degrees.

5. Can you tell in what ways
 - a) an oven thermometer is different from a freezer thermometer? (The range of degrees is higher in the oven thermometer.)
 - b) the thermometer a doctor uses to take the temperature of his patient is different from the thermometer used by a weather forecaster? (The range of a clinical thermometer is from about 94° to 110°; the range of an outdoor thermometer is from about 30°F. below zero to about 120°F.)
6. One morning the outdoor thermometer of a classroom read 19°. When the children measured the temperature in the afternoon, the thermometer reading was 26°.
 - a) Which way did the line in the thermometer go? (Up.)
 - b) Did it get warmer or colder? (Warmer.)
 - c) How much difference was there in the temperature? (7°.)
 - d) What season of the year do you think it was? (Winter.)
7. Why do the following people use thermometers?

a) cooks	d) candy makers
b) doctors	e) housewives
c) weather observers	f) grocers

B. WIND

Background for the Teacher

Wind, as defined by the meteorologist, refers to *horizontal* air motion, as distinct from vertical motion. To measure the wind is to determine its direction and speed. The wind vane measures direction. (It is more popularly called the weather vane, since men have known for a long time that wind direction has an important bearing on the weather.) A wind vane points *into* the wind, that is, toward the direction *from* which the wind is blowing. For example, if a wind is blowing from the west, the arrowhead points to the west. Winds are named by the direction *from* which they come. A wind blowing from west to east is designated a west wind.

The speed of the wind is measured by an instrument called an anemometer. A common type used by weather bureaus is the three-cup anemometer. Each cup is a hollow hemisphere. The three cups are attached by spokes to a central pivot. It is usually positioned on an unobstructed roof. The wind spins the cups around as it would a pinwheel, at a speed that is proportional to the wind speed. The speed is indicated on a device located inside the weather bureau. The direction and speed of winds higher above the earth are determined by meteorologists, using airplanes and balloons.

Approaches and Learnings for the Child

Wind direction and wind speed are part of the daily weather reports in newspapers and on the radio and television. Children can make their own observations and estimates by watching the wind at work in their own environment. The fluttering of leaves, the blowing of flags, and the drifting of smoke give children clues about the direction and speed of the wind. As they make and use wind vanes and anemometers, they realize that there are more exact ways of measuring the wind.

From the activities suggested, children learn the following.

Wind direction may be detected by observing smoke, trees, flags, and clothes on a line.

Wind direction is measured with a wind vane.

The direction FROM which a wind blows gives the wind its name.

Wind speed is measured with an anemometer.

Wind direction and speed may change from day to day.

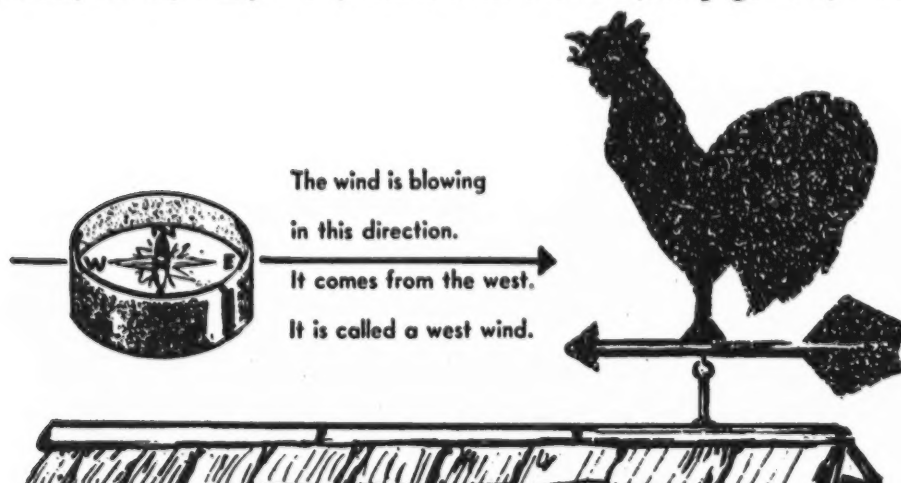
1. How can we tell which way the wind is blowing without going outdoors?

Children will suggest looking at smoke from chimneys and at flags and clothes blowing. Encourage children to look for those and other signs to determine which way the wind is blowing.

- *We can tell which way the wind is blowing by looking at smoke, flags, and clothes on lines.*

2. How do the winds get their names?

Make certain that the children can orient themselves to the directions (North, South, East, West) around the school. (See page 157). Take



the class outdoors on a breezy day. Ask, "Where is the wind coming from"? Children face the wind and point into it. "The wind is coming from this direction." If they do not know the direction, point it out to them. For example, if the wind is coming from the west, the child should be facing west. He should point west and call the wind a *west wind*.

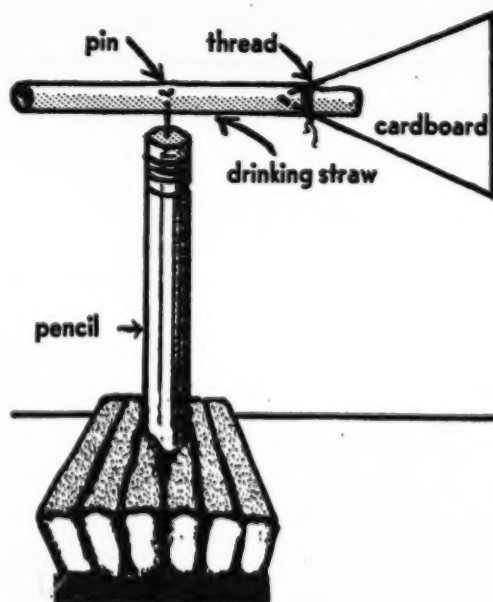
- *Winds are named by the direction from which they come.*

3. How does a wind vane tell us the direction of the wind?

Show the children a wind vane that may be used out of doors. Take them to the street or playground to observe the wind vane in operation. Ask them to tell about weathervanes they may have seen on houses, church steeples, or at airports. Encourage them to construct wind vanes.

Following is one type of wind vane construction.

Use a 2½ inch length of a drinking straw, as shown. (A plastic straw makes a more durable instrument.)



A homemade wind vane.

In the following instructions the teacher should handle the safety pin, candle, and razor blade, and have the children help in other aspects of the construction. Make a bearing hole through the straw, about one inch from one end, by piercing it with a large safety pin which has been heated in a candle flame. After the hole is made, a thinner straight pin is substituted. An accurate slit should be made in one end of the straw. (Do this for the child, using a single-edged razor blade and working carefully.) The vane is inserted into this slit and wedged in place. (For greater permanency, use a drop of glue or whip several turns of sewing thread around the slit to bind the vane to the straw.)

Some children may wish to make larger wind vanes to be placed in an open area, visible from the classroom.

When held in a wind, the wind vane points into the wind, towards the direction *from* which the wind blows. This direction also gives a wind its name. In order to point accurately, a wind vane must swing freely. It must have more surface on the tail side than on the pointer side.

The wind vane must be in an open area which receives the wind directly and not reflected currents from it. The class may make a record of the wind and weather for several weeks and study it to discover possible relationships between wind direction and weather. They will discover that a north wind generally brings cooler weather, in this part of the country. A west wind is usually a good weather wind. An east wind frequently precedes wet weather. A south wind often brings warm, moist weather.

Help the class develop a chart that relates wind to weather. It may be constructed in this manner.

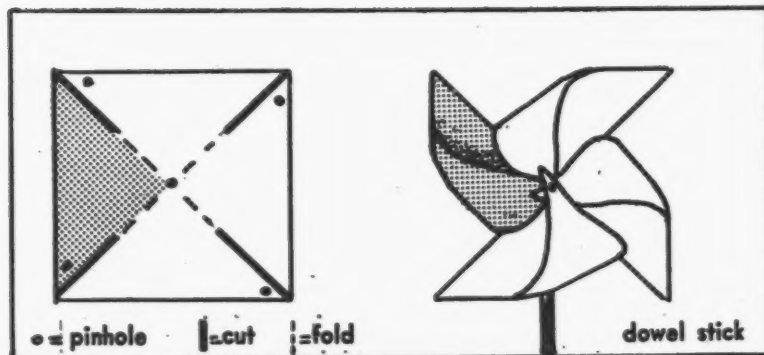
Date	Time	Direction of Wind	Weather
5/20/65	9:30 A.M.	West	Fair
5/21/65	9:30 A.M.	East	Cloudy
5/22/65	9:45 A.M.	West	Fair
5/23/65	10:00 A.M.	East	Drizzle
5/24/65	10:00 A.M.	South	Warm

- *A wind vane helps us find the direction of the wind.*
- *The arrow of the wind vane points into the wind.*
- *The wind is named for the direction from which it blows.*
- *Sometimes the wind helps us to predict what kind of weather we will have.*

4. How strong is the wind today?

Some children may know of the anemometer used by weather observers and homeowners to gauge the speed of the wind. (See *Background for the Teacher*, page 99.) A simple pinwheel illustrates the principle of the anemometer. Have children construct pinwheels. Color one point to make it easier to count or estimate the number of turns made in a given period of time. Ask the children to blow on their pinwheels, first gently and then vigorously. They will understand that the stronger the "breeze," the faster the pinwheel turns. Let children try out their pinwheels indoors near open windows, and outdoors in various locations. Children will begin to understand that a free spinning object, such as a pinwheel, may be used to gauge the speed of the wind.

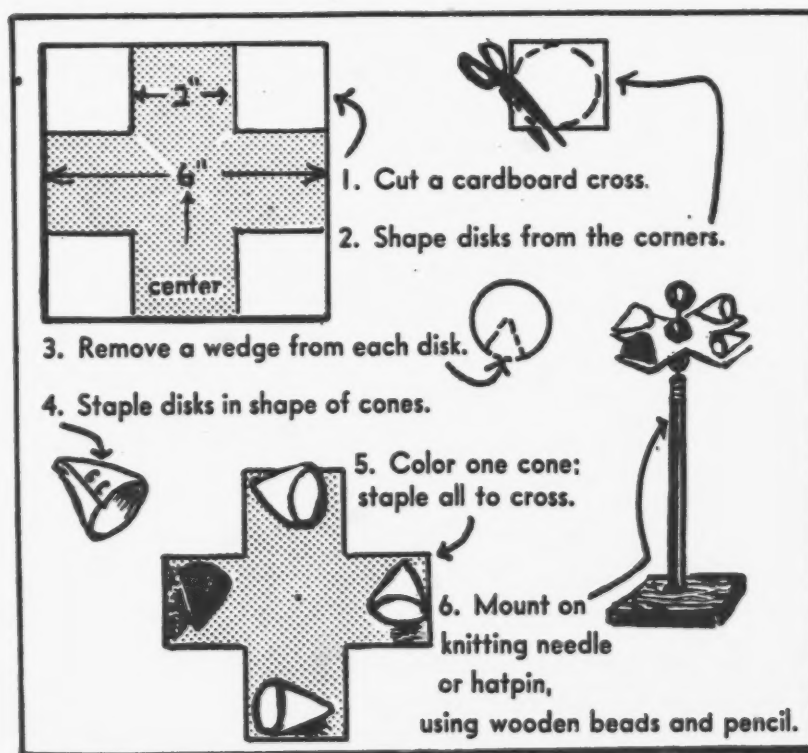
Have children observe the pinwheel in an open outdoor area for a number of days. Does it seem to spin faster on some days than on others?



Making a pinwheel.

Can children count the number of turns made in a minute? (Probably not, unless there is a very gentle breeze.) The weatherman's anemometer transfers the "information" about the rate of spinning to a dial, where it may be read easily.

Another type of homemade anemometer is shown below.



A homemade anemometer.

- The wind makes the anemometer spin around.
- The faster the wind moves, the more quickly the pinwheel spins.
- The wind speed may change from day to day.

5. How can we tell the wind's speed without an instrument?

Go outdoors when the wind is blowing. Look for the movement of leaves, signs, and flags. Observe papers and dust blown by the wind. Children may use the following scale to determine wind speed. They may add the wind speed and direction to their daily weather report.

SIGNS	NAME OF WIND	MILES PER HOUR
Flags hang down; smoke goes straight up; leaves do not move.	Calm	0
Wind moves leaves on trees; is felt on face; blows out light-weight flags.	Light Breeze	1-5
Wind moves branches of trees, blows dust and loose papers about.	Gentle Breeze	5-15
Wind sways branches; raises whitecaps on water.	Fresh Breeze	15-25
Wind makes it hard to use umbrellas; whistles in trees and wires; sways whole trees.	Strong Wind	25-35
Wind breaks branches; uproots trees; damages houses; is hard to walk against.	Gale	35-75
Wind damages houses; blows down utility poles and trees; causes great damage.	Hurricane	75-100

- *We can get some idea of the wind speed by noticing what happens to the objects the wind blows on.*

EVALUATIVE ACTIVITIES

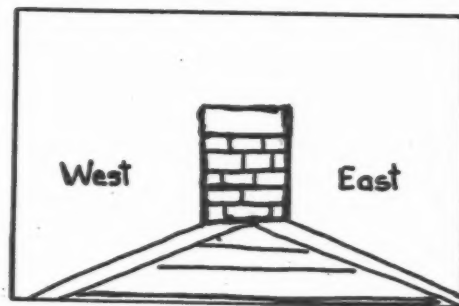
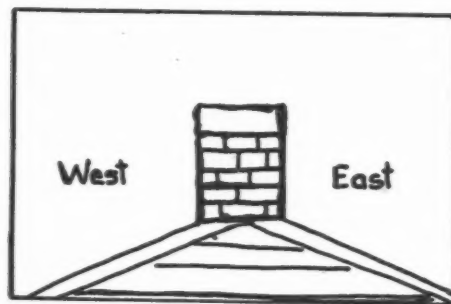
1. Which way is the wind blowing right now?

(Do children determine direction by observing the signals suggested in Problem 1? Do children point in the correct direction? Are they able to name the wind?)

GRADE THREE

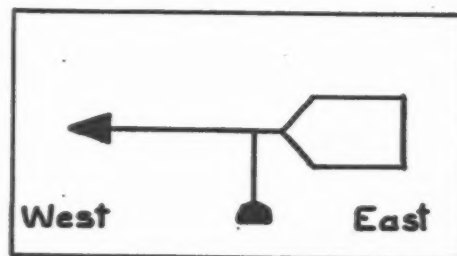
2. Complete these two illustrations.

- Draw smoke coming from the chimney in the first illustration to show a wind blowing from the West. (Toward the right.) What is the name of the wind? (West wind.)
- Draw smoke coming from the second chimney, to show a wind blowing from the east. (Toward the left.) What is the name of the wind? (East wind.)



3. This wind vane is in the wind. The wind is blowing from where to where? (West to East.)

It is called a wind. (West.)



- How can you tell, without going outdoors, how strong the wind is today? (Observe flags, smoke, leaves, people, dust, and papers.)
 - Give children the wind scale shown in Problem 5. Ask them to use it to find the name of the wind, and the number of miles per hour. Call the United States Weather Bureau (WE 6-1212) to compare their findings with that given by the Weather Bureau. Why might it be different? (It might be windier at the Weather Bureau Station; the Weather Bureau may have more accurate instruments.) What does the Weather Bureau use to measure the speed of the winds? (Anemometer.) How does it work? (Cups catch the wind, the anemometer spins, the speed is shown on a dial; the faster the wind the faster the spinning.)

C. RAIN, SNOW AND WATER VAPOR

Background for the Teacher

We are all familiar with the old saying, "It's not the heat, it's the humidity." Most people prefer dry days, whether cold or hot, to the damp, humid kind of day in which clothing, furniture, and walls feel moist and sticky. Humidity is the moisture in the air. Where does the water come from and how does it get into the air? Bodies of water—oceans, rivers, lakes, and streams—make up more than 72 percent of the earth's surface. The molecules of water in these bodies are in constant motion. Many of the molecules at the surface of the water escape into the air as they bounce about. The heat produced by the sun's rays increases the motion of the molecules and speeds evaporation.

Water evaporates into the atmosphere in a gaseous state, as invisible water vapor. Warm air can hold more water vapor than cold air. When warm, moist air is cooled, some of the water vapor condenses into water again, forming tiny water droplets on small particles of dust suspended in the air. These droplets form clouds. Rain occurs when the droplets join together to form bigger and heavier drops. Meteorologists still do not completely understand the causes of this phenomenon.

Snowflakes may be formed in clouds when the temperature of the air is below freezing. At such times vapor may condense directly into ice crystals, or snow. High clouds, or the upper parts of some clouds, are often made completely of ice crystals. In other words, the water changes from the gaseous state directly to the solid, by-passing the liquid state.

The weatherman keeps a record of each rainfall. Rain is collected in rain gauges. The method used by the weatherman to determine the number of inches of snowfall is similar to the method used with the children in *Problem 2*.

The hygrometer is the instrument used by weathermen to measure the humidity of the air. In the *hair hygrometer*, the indicator is activated by a human hair, which lengthens when the air is moist and shortens when the air is dry. A more accurate kind of hygrometer is the *wet-and-dry-bulb thermometer*.

Approaches and Learnings for the Child

Water appears in many forms: rain, dew, fog, frost, snow, clouds, hail, sleet. The weatherman is concerned with the detection and measurement of these visible forms of water. He is also concerned with the measurement of water in the air in its invisible form, water vapor.

Children are interested in making and using instruments for measuring rainfall. After a snowfall they measure the depth of the snow and melt some to see how much water results. They make an instrument to determine the amount of humidity in the air, using a chemical which changes color with a change in the humidity.

From the activities suggested, children learn the following.

Rainfall may be measured collecting rain in a jar.

Snowfall may be measured with a ruler.

When snow melts into water, the water takes up less space than the snow did.

Air may contain invisible water vapor.

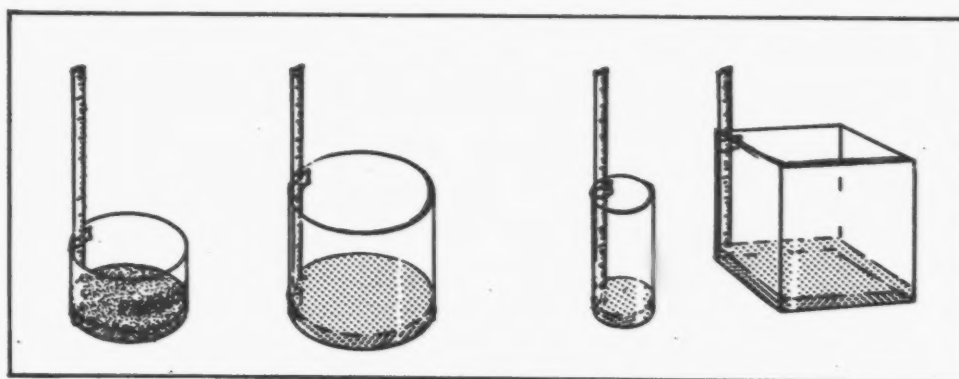
Water evaporates into the air from wet surfaces.

The humidity (dampness) of the air may change from day to day.

1. How can we measure the amount of rainfall?

After a rainfall, go outdoors with the children and observe the dampness of soil, sidewalks, plants, and debris in the streets. Observe the size and depth of the puddles. Ask children how much rain has fallen. They may answer "a little" or "a lot." Ask them to think of ways to be more exact or precise about the measurement of rainfall. Some may suggest collecting the water in a container and then measuring the height of the water level with a ruler, the next time it rains.

Have children place their different containers outdoors or on window sills. They may keep records by measuring the depth of the water with a ruler. Have them compare the results in each of the different containers. (The *size* of the container should not affect the level reached, provided its walls are vertical.)



**All these containers were exposed to the same rainfall.
The depth of the water in each is the same.**

If it rains and no appreciable amount can be measured by a ruler, we say we have had a *trace* of rainfall.

Have children keep a record of rainfall for a month. Make a chart for this purpose or use a large calendar.

- *Rainfall may be measured by collecting rain in a container and measuring the depth of the water with a ruler.*

2. How is snowfall measured?



"Eleven inches!"

After a snowfall, ask children how they could measure the fallen snow. They may suggest thrusting a stick, ruler, or yardstick into the snow.

Take children outdoors. Have them measure the snowfall in different places with several sticks or yardsticks. Compare the measurements.

Do all agree? (Not always.) Why? (The snow is blown by the wind and piles up in some places.) How can we be sure of a correct measurement? (Choose a place where there has not been much drifting.)

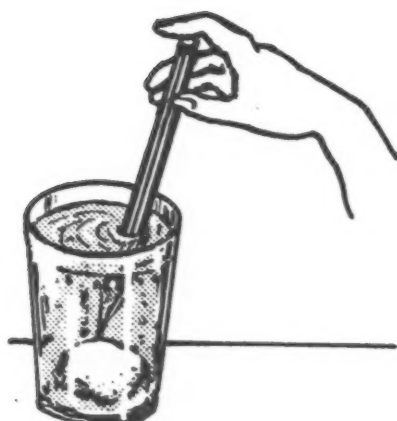
What is another way? (Consider the average depth, or the amount which is measured most frequently, as the amount of snowfall.)

Find out from newspaper, radio, or television reports what figure the Weather Bureau gives for the snowfall. How does this compare with the class's finding?

- *The depth of the snow can be measured with a ruler.*

3. What happens to a container full of snow when it is brought indoors?

Place an open container, such as a coffee can, in an open area outside the classroom at the beginning of a snowfall, or scoop up a can full of snow, making sure not to pack it. Mark the level of the snow with ink, tape, or other means at hand. Take the container indoors and allow the snow to melt. Mark the level of the water. Let the children measure both levels with a ruler and formulate ideas about the difference between them. Why does the water take up less space? Encourage children to suggest an explanation. Some may suggest that the snow has air in it.



A snowball has air in it.

To find evidence of the presence of air in snow, do the following. Place a snowball in a container of water. The snowball will float, indicating that it is lighter than water, and suggesting the presence of air. Push the snowball into the water with a pencil and hold it down.

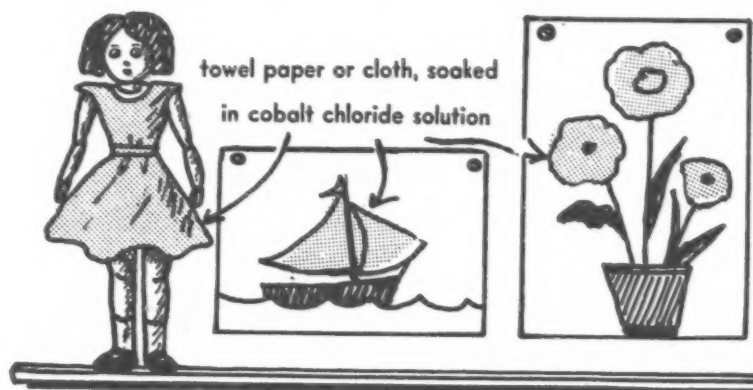
What are the bubbles that begin to come out of the snowball and rise to the surface? (Air bubbles.)

- *When snow melts to water, the water takes up less space.*
- *Air escapes from snow when it melts.*

4. How can we find out if the air is damp or dry today?

On a damp day ask children to feel the walls, windows, and their clothing and tell about the dampness they notice. How can we find out, without feeling walls and windows, if the air is damp?

Show children the chemical *cobalt chloride* (on the E-1 List) and tell them that this chemical changes color according to the dryness or dampness of the air. Have the children make cobalt chloride indicators in the following way. First, dissolve some cobalt chloride in water. (*Precaution:* children should be told not to taste cobalt chloride crystals or solution. After working with the solution, hands should be thoroughly washed.) Then have children soak pipe cleaners, unbleached muslin, or paper toweling in the solution. Remove them and allow them to dry. These may be pinned up and observed or used in devices such as those below.



Three humidity indicators.



Testing the humidity indicator under known conditions.

To help the children understand how the indicator works, suspend a strip of paper toweling (previously treated with cobalt chloride and allowed to dry) in each of two jars. Attach the strip to the underside of the jar covers. One of these will have moist air in it, provided from an inch of water added to the jar before putting on the cover. The other will have dry air in it, obtained by placing the open jar on a radiator, over a hotplate or over a lighted electric bulb for a few minutes before covering it. Children will observe the color of the paper in these known conditions, and will therefore have a better basis for understanding how this instrument may be used to measure unknown conditions.

Tape one piece of prepared toweling outside the window and another inside. Compare for several days. *Note:* As a *weather* instrument the indicator must be observed outdoors, since the humidity of the air inside the classroom will be altered by other factors, such as heating by radiators.

The material soaked in cobalt chloride will be blue in dry weather, and will gradually turn pink as the humidity increases.

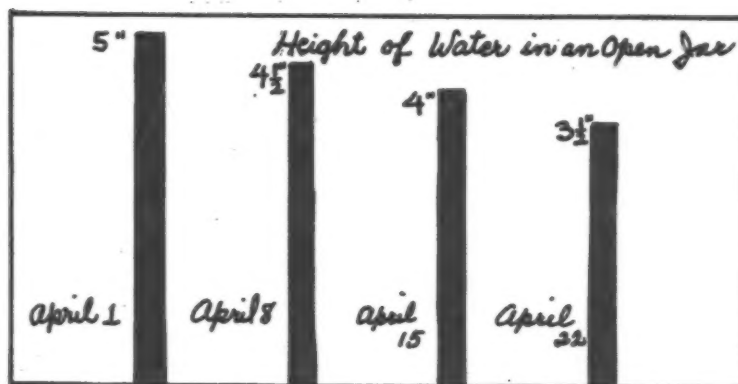
Keep a record of the outdoor humidity for several days.

- *The cobalt chloride indicator shows whether the air is dry or damp.*
- *The humidity (dampness) of the air may change from day to day.*
- *The humidity inside may be different from the humidity outside.*

5. What happens to the water in puddles?

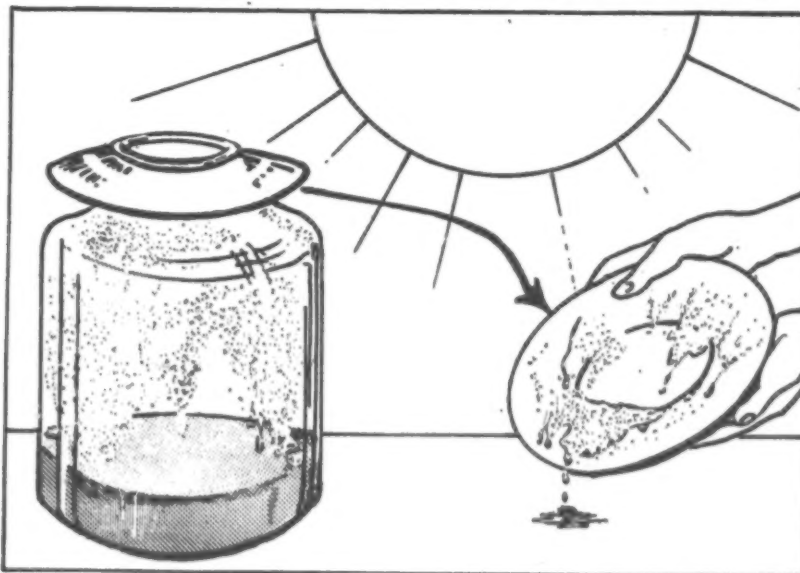
Children may offer a variety of plausible answers to this question. "There was a hole in the ground and it sunk in." "The super swept it away." "It went away by itself." "It went into the air."

Ask children how they can experiment with water to determine if the water does go into the air. Some children may suggest leaving a dish of water open and observing it each day. Try as many of the children's suggestions as feasible. The following experiments are typical.



a. *Covered and uncovered jars*

Place two similar jars, with equal amounts of water, in sunlight. Cover one and leave the other open. Indicate, by a felt-pen mark, the daily level of the water in each jar. Make a graph to show the changes in water level. Have children form conclusions about the results. Ask children what happened to the water which had been in the open jar. (Evidently it went into the air.) In the closed jar? (It is still there, either on the bottom, or on the sides or top of the jar, or in the air in the jar.)



b. *Sunlight and shade*

Place one open jar of water in sunlight and one similar open jar, with an equal amount of water, in a shady spot in the room. Check each jar for a period of few weeks. Keep records and make graphs of the results. What effect does sunlight have on the evaporation of water?

c. *Narrow jars and flat dishes*

Place the same (measured) small amount of water in an open dish as in a narrow, open olive jar. Keep both containers under the same condi-

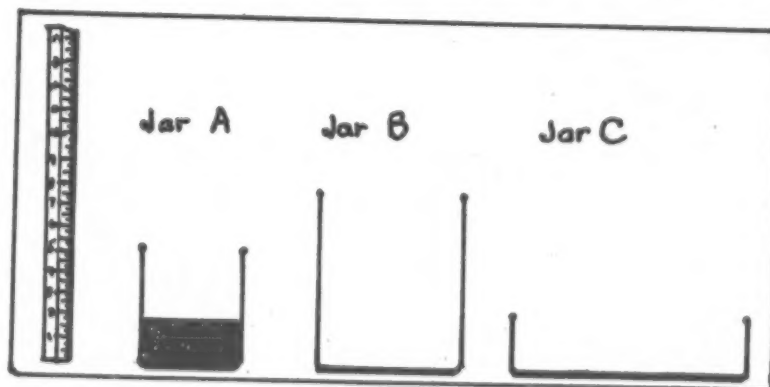
tions. In which does the water evaporate faster? To keep the record, it may be advisable to measure the amount of water in each container at intervals, by pouring the contents of each into a measuring cup and then returning it to its container. Have children discuss how the surface area of the water affects the speed of evaporation.

Relate the evaporation experiences above to evaporation under natural conditions from the surface of ponds, lakes, streams, and oceans.

- *Water gets into the air from wet surfaces. This process is called evaporation.*
- *Sunlight hastens evaporation.*
- *Evaporation is faster from a larger surface than from a smaller one.*

EVALUATIVE ACTIVITIES

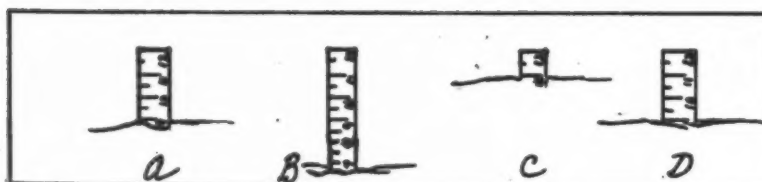
1. To collect rain, a boy put 3 empty jars outdoors at the same time. How much rain fell in Jar A? (2 inches.) Show where the rainwater level will be in Jar B. (Should be the same height as Jar A.) How high is the water in Jar B? (2 inches.) Show where the rainwater level will be in Jar C. (Should be the same height as Jar A.) How high is the water in Jar C? (2 inches.)



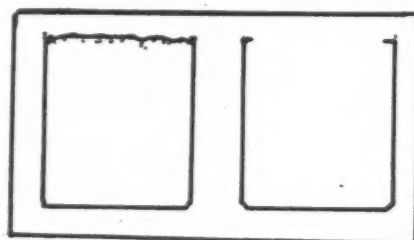
2. After a snowfall, children went outdoors near their school with rulers to measure the snowfall. How should they use the rulers? (Push them straight down into the snow until they reach the ground and read the number of inches.)

The following illustration shows what four children saw.

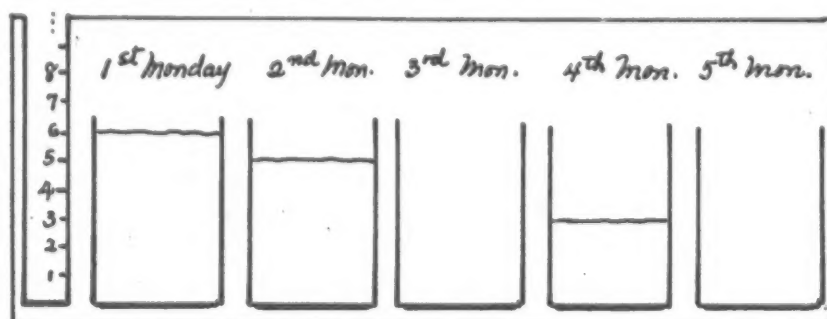
How high was the snow pile measured by each of the children? (A-9 inches, B-7 inches; C-11 inches; D-9 inches.) Why did they get different results? (The snow may have drifted; some children did not push their stick down to the ground.) If you had to send in a report to the Weather Bureau how would you report the snowfall for these four records? (Between 7 and 11 inches; average of 9 inches.)



3. Here are two jars. One is filled with snow.
In the other one show what the snow will look like after it has melted. (Less space, in the form of water.) Why does snow take up more space? (It has air in it.)



4. What is happening to the air when the cobalt chloride indicator changes from pink to blue? (The air is becoming drier.) What is happening to the air when the cobalt chloride indicator changes from blue to pink? (The air is becoming moister.) What is happening when the color does not change? (The air humidity is not changing.)
5. On Monday a boy poured water into a jar, as shown in the illustration.
- How high was the water level on the first Monday? (6 inches.)
 - What was the water level on the second Monday? (5 inches.)
 - On the fourth Monday? (3 inches.)
 - Show where the water level might be on the third Monday. How high is it? (4 inches.)
 - Do the same for the fifth Monday? How high is it? (2 inches.)
 - Where did the water go? (It probably evaporated; it went into the air.)



BASIC SUPPLY LIST

FOR OBSERVING AND MEASURING WEATHER CHANGES

*Indicates quantity for entire class; other quantities
specified are for each group of 4 children

E-1: Science Supply List

1 Thermometer	*1 Hot Plate	1 Candle
1 Outdoor Mounting Bracket for thermometer	*5 lbs. Soil	*1 half-bottle Cobalt Chloride
*Assorted Thermometers	*5 lbs. Sand	
	*2 plastic Saucers	

G-1: General Supply List

1 Ruler, 12"	4 straight Pins	1 jar Paste
1 Ruler, 18"	1 Safety Pin	1 pair Scissors
10 sheets Drawing Paper	1 paper Cup	4 paper Towels
1 sheet Oaktag, small	4 Pencils, with Erasers	*1 piece Unbleached Muslin, 12" x 12"
2 sheets Oaktag, large	1 Board Eraser	
4 Drinking Straws	1 spool Thread	*1 roll Cellophane Tape

Miscellaneous:

*1 Razor Blade—single edge	*1 Coffee Can	1 tray Ice Cubes
4 assorted Containers	2 glass Jars, (uniform size)	1 pkg. Pipe Cleaners
	*1 narrow Olive Jar	





Friction, Gravity and Motion

A. FRICTION AFFECTS MOTION

Background for the Teacher

We tend to think of friction as an unwanted, unpleasant phenomenon. Actually, friction makes it possible for us to perform many of our daily activities. If it were not for friction, doorknobs would slip through our hands without turning, chalk would not write on chalkboards, a match would not light when struck, pencil writing could not be erased. Of course it is also true that friction makes some operations so difficult that in these cases we try to reduce it.

What causes friction? Friction takes place whenever two surfaces rub against each other. Every surface has many irregularities. On rough surfaces these bumps and cavities can be seen and felt easily. On a smooth surface they can be seen through a magnifying glass or microscope. Friction is caused by the bumping and ripping of these irregularities as they slide over each other.

One way to reduce friction between surfaces is to make one roll over the other, rather than slide over it. Thus the use of rollers or wheels makes it possible to push or pull heavy loads over land more easily. Similarly, ball bearings or roller bearings, placed between the center hole of a wheel and its axle, reduce friction by substituting rolling for sliding.

Recent studies show that friction is also caused by the attraction of the molecules of one surface to the molecules of another surface. Lubrication reduces friction because it fills in the irregularities of the surfaces and because it separates the attracting surfaces.

Whatever its cause, bumpiness or molecular attraction or both, friction acts as a force which opposes the movement of one surface over another. As a result of this resistance, some of the energy of motion is converted into heat. We rub our cold hands deliberately so that friction can warm them up. When a wheel turns an axle, the surfaces of the wheel and the axle in contact with each other heat up. Since lubrication reduces friction, it also reduces this loss of energy.

Approaches and Learnings for the Child

Children approach the study of friction by investigating the surfaces of common objects and materials for their roughness or smoothness. They use a simple device—a rubber band attached to a block of wood—as an instrument for testing the smoothness of various surfaces. They look at surfaces with a magnifying glass to find the many “hills” and “valleys” which are different in character with each kind of surface. They learn that friction results from the catching and tearing of these irregularities as two surfaces slide over each other. They investigate methods of reducing friction: lubrication, and the use of rollers, wheels, and bearings. Sometimes we want to increase friction. Children know that we scatter sand on icy roads, put chains on tires; that a baseball batter rubs his hands with soil. All of these reduce unwanted slipperiness by making the surfaces rougher.

From the activities suggested, children learn the following.

When two surfaces rub against each other, there is friction between them.

Friction is decreased by using lubricants between the surfaces and by making surfaces smoother.

Friction between two surfaces is decreased by using rollers, wheels, and bearings.

Sometimes friction helps us.

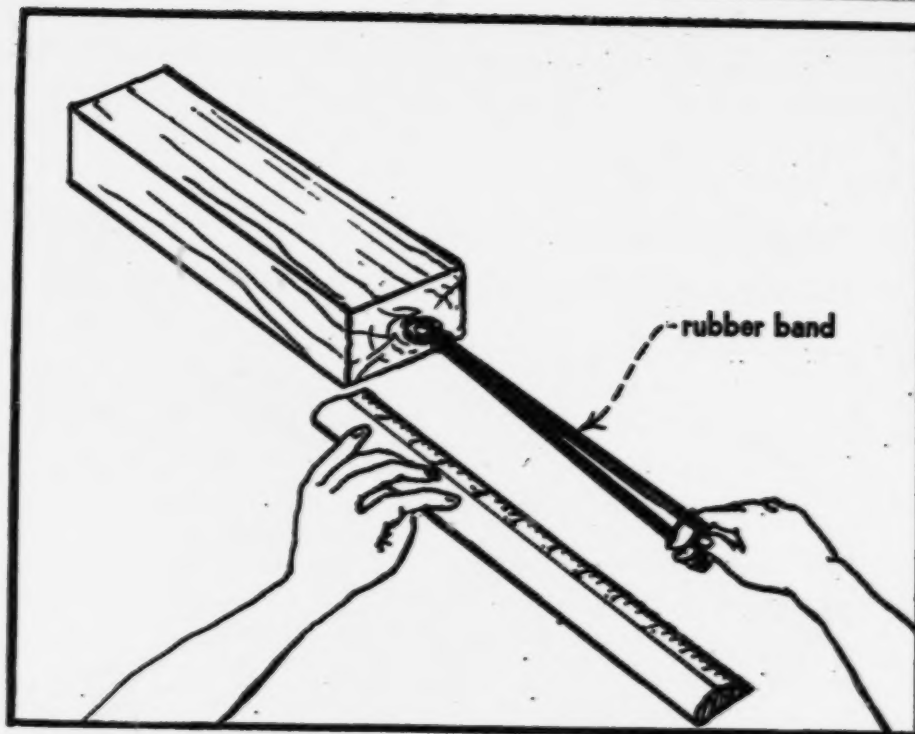
Friction is increased by making surfaces rougher.

1. On what kinds of surfaces do things slide best?

Ask children to recall sliding on ice, on waxed floors, wet floors, smooth stone steps, smooth metal subway gratings. Have children feel the surface of various objects and materials for smoothness and roughness. Ask them on which surfaces they would be more likely to slide.

In order to compare the smoothness of different surfaces, children may make the device shown in the following illustration.

Attach a rubber band to a block of wood, a book, or any other convenient object. Drag the object by pulling on the rubber band. Children should understand that the harder it is to drag the object, the farther the rubber band stretches. By measuring the stretch of the rubber band in inches, the children compare the amount of pull needed to move the object over various surfaces. *Note:* Instead of a rubber band, a spring scale may be used to measure the pull in ounces.



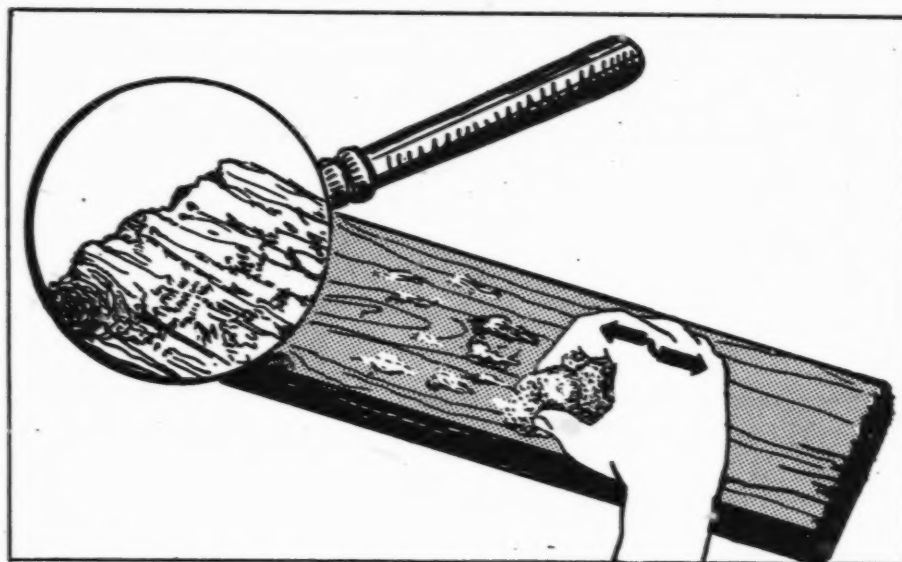
The stretch of a rubber band tells us how easily the block slides.

Smooth and Rough	
Kind of Surface	Stretch of rubber band, in inches
1. Table top	$\frac{1}{2}$ "
2. Desk blotter	2"
3. Sandpaper	
4. Corrugated board	
5. Kindergarten sand table	
6.	

A hunt for smooth and rough surfaces can be conducted in the classroom or other parts of the school building. Gymnasium floors, staircases, playgrounds, classroom floors, table or desk tops, kindergarten sand tables, large sheets of sandpaper, corrugated paper, and other materials are possibilities for investigation. Have children record the amount of stretch in each case and find out which surface is the most slippery.

Discuss the safety precautions we take to prevent slipping and skidding. Children may want to discuss the purpose of wearing sneakers for physical education and sports. The use of snow tires on vehicles is now a matter of law on so-called "snow streets" and ought to be discussed. *Note:* Snow tires are of very little help on ice.

- *Things usually slide better on smooth surfaces than on rough ones.*
- *Things usually slide better on wet surfaces than on dry ones.*



Snagged tufts of cotton tell how rough the wood is.

2. Why is it easier to pull a load on a smooth surface than on a rough one?

From the previous problem, the children have learned that it is easier to make an object slide over a smooth surface than over a rough one. Ask them to express their thoughts as to what makes a surface rough or smooth. They may say that a rough surface is bumpy, scratchy, uneven, or has sharp points which stick up.

Have the children examine, first with the unaided eye and then with a magnifying glass, the area of bare, exposed wood on a freshly-sharpened pencil and compare it with a piece of rough wood. They will then become aware of the irregularities of even the smoother wood. Children should be encouraged to describe what they see.

Have them rub a piece of absorbent cotton over the surface of rough wood. Now ask them to rub absorbent cotton on a smooth desk top. Examine the desk surface with a magnifier. They notice fewer irregularities and see that no cotton is caught on the surface.

Have children rub two rough surfaces together and describe what they feel and see. They learn that when two surfaces rub together, their surface bumps and projections interfere with the motion of the objects, making them catch against each other. This catching, which keeps things from moving freely, is friction.

- *When two rough surfaces rub against each other there is friction between them.*
- *Rough surfaces have many large bumps.*
- *Smooth surfaces have few small bumps.*
- *When objects with rough surfaces are rubbed together, the bumps catch. This makes it difficult to move the objects.*
- *When objects with smooth surfaces are rubbed together, there are fewer and smaller bumps to catch. This makes it easy to move the objects.*

3. How can we make things slide more easily?

Have children slide one piece of rough wood over another. Ask them to suggest ways of making the wood slide more easily. Some children may suggest sandpapering the wood. Before sandpapering, examine the wood with a magnifier. Examine the wood again after sandpapering. Try rubbing the pieces of wood together again to see if there is a difference in the way they slide against each other.

Ask the children if there are any other ways of making things slide or move easier. They may suggest putting something slippery between two pieces of wood. Try lubricating the surface with soap, wax, vaseline, or other oily or slippery materials. Note how much easier it is now to move the pieces as they rub against each other. Observe how the lubricant fills the spaces between the bumps, thereby making the surfaces smoother.

Conduct a "squeak hunt." Have children look for sliding doors or hinged joints which squeak when moved. Add oil or any of the lubricants mentioned to see if this does away with the squeak. *Note: Do not use oil on door locks.*

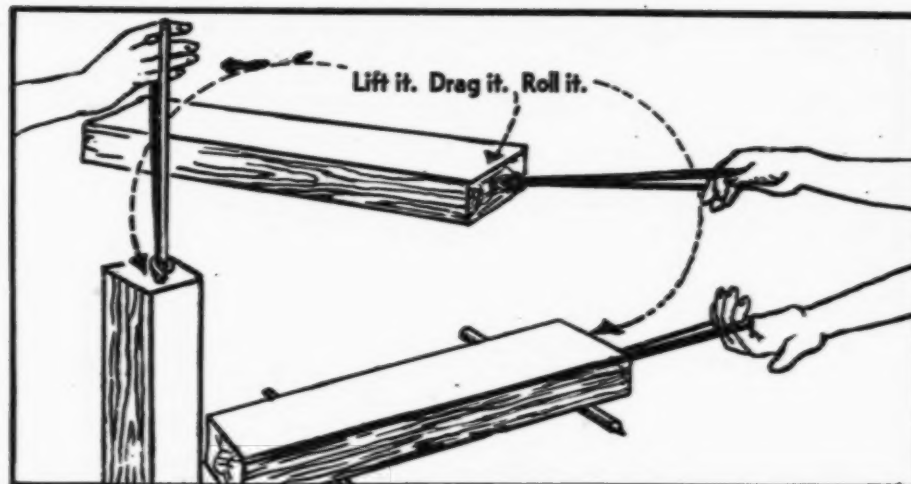
- *We can decrease friction by making surfaces smoother.*
- *We can decrease friction by putting lubricants between the surfaces.*

4. Is it easier to move a load on rollers than to drag it?

Obtain a long, heavy block of wood and ask children to suggest ways of moving this load from one place to another. Some children may suggest lifting and carrying it, others may suggest dragging it or pushing it, while others may wish to move it along more easily by using rollers.

How can we be certain that one method is easier than another? Ask the class to recall how a rubber band was used in *Problem 1* to measure the force needed to slide something over smooth or rough surfaces. Now ask the children to devise an experiment using this measuring device to find whether it is easier to lift, slide, or roll an object.

Have the children do the following. First, lift the load by the rubber band. Use a ruler to measure the total stretch as accurately as possible, and



The stretch of the rubber band tells us which is easiest.

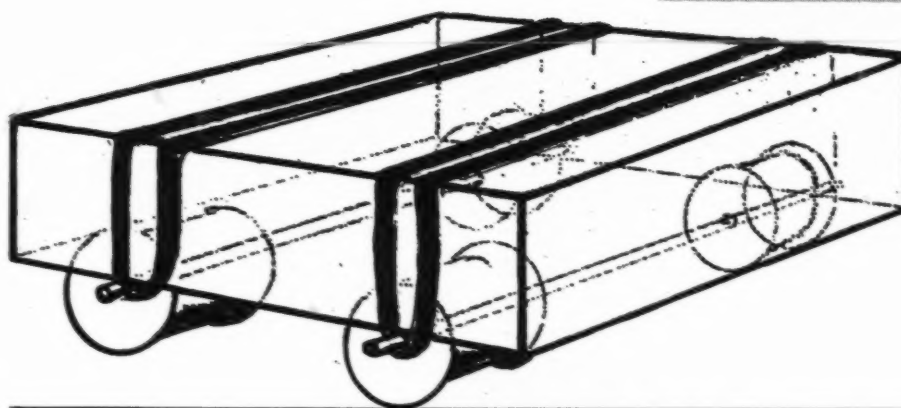
record it. Then, drag the load by the rubber band and again record the stretch. Finally, measure the stretch when the load is supported on smooth, round pencils on which it is rolled. Help the children make a chart of these measurements. Encourage them to discuss their conclusions.

- *It is easier to drag a load than to lift it.*
- *It is easier to move a load on rollers than to drag it.*

5. Why are wheels better than rollers for moving a vehicle?

Ask the children to name the disadvantages of using rollers under a vehicle. They may point out that the rollers move toward the rear, that they finally come out in back and have to be replaced under the front part of the vehicle. They may also see the difficulty in steering.

Many activities and learning situations can stem from the use of a simple, homemade wagon. Four similar-sized spools are used for wheels. The front and rear axles are thin round pencils, lollipop sticks, or knitting needles, which fit loosely into the holes in the spools. The axles are held in place under a small, inverted box by means of rubber bands. Another box, up-right, can be stapled to the inverted one.



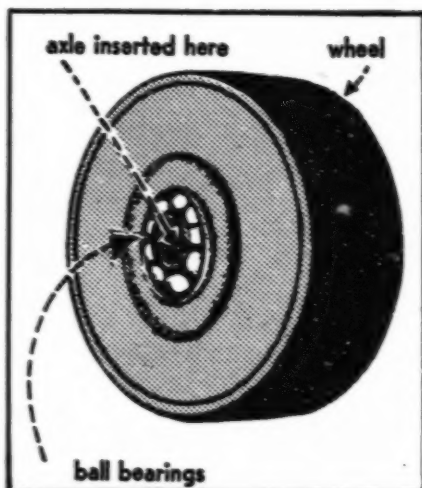
Each child can make a wagon like this.

A gentle push will make the wagon roll for quite a distance. Compare this with the distance the wagon will slide when given a similar push while upside down on the table, that is, off the wheels.

How large a load can be placed in the wagon? Can it be steered? Try changing the angle of the front-wheel axle. What happens? Can a wagon be steered when going backwards by moving the front axle? If so, in what direction? Point out that this is what happens when an automobile backs into a parking space.

- *Wheels make it easier to move things.*
- *Wheels and rollers reduce friction.*

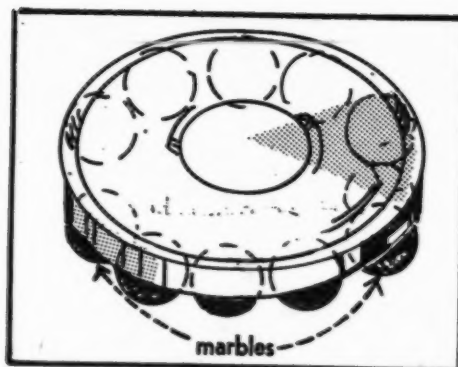
6. Why can you go faster on ball-bearing skates than on learner's skates?



Ball bearings reduce friction between axle and wheel.

Have children bring all kinds of roller skates from home. Have them pull each of the skates with the same rubber band to find out which of the skates rolls most easily. Make sure they understand that the skate which causes the rubber band to stretch least is the best roller.

The children discover that the skate which moves most easily contains ball bearings. If possible, remove a wheel from a skate with ball bearings to examine the small steel balls near the axle.



A book can easily be made to spin on this "Lazy Susan"

To demonstrate how ball bearings decrease the force required to move objects, place a twist-off jar lid or the top of an oatmeal box, lid down, on a table. Place a heavy book on top and ask the children to spin the book. They discover that it does not move easily. Now remove the book and place some marbles under the lid. Make sure the marbles are large enough to allow the lid to clear the table. Replace the book and have a child again try to spin it. The class will see that the book moves with ease and for a longer period of time. It rotates as on a "Lazy Susan."

Ask the children to name other objects such as bicycles, casters, and toys on which ball bearings are used. Notice how ball bearings help by substituting rolling friction, between wheel and axle, for sliding friction.

Can round objects be dangerous on floors and stairs?

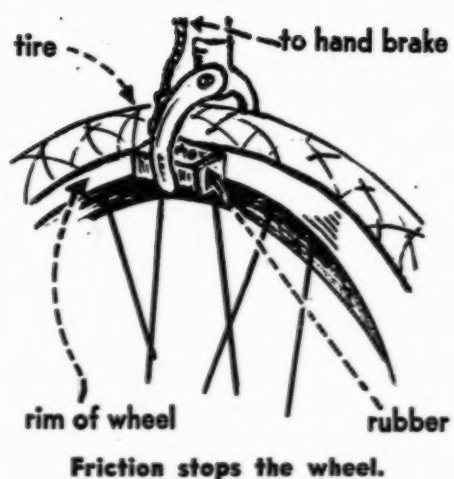
- *Ball bearings reduce friction between wheel and axle.*
- *Wheels turn more easily when they are on ball bearings.*

7. How does friction help us?

Ask children whether they have seen cut-away drums used as containers for sand, and strategically placed at entrances and exits of expressways, and at approaches to hilly stretches of road. These are provided so that motorists may spread the sand under the wheels of their cars in the winter-time to make the roadway less slippery. Sand or ashes also be used on sidewalks to prevent slipping on the ice. Take the class out on a cold day to experiment with sand or ashes on icy patches in the school yard or sidewalk near the school. Children should be allowed to examine the sand or ashes to feel how rough they are.

Have children try to open the tightly closed screw-on lid of a jar, first with bare wet hands and then with a dry rough cloth or towel over the lid. They will observe that their wet hands may slip on the lid. They also see that rough cloth makes it possible to get a better grip on the jar lid.

GRADE THREE



Some children may recall that bicycles with hand brakes stop when the brake shoe is pressed against the rim of the wheel. They may have noted that when the brakes or the wheel are wet, the brakes slip and do not stop the wheel as quickly as when they are dry. Does this explain why we must take extra care when crossing streets in wet weather? (Autos have similar difficulty in stopping.)

Children should be able to explain why friction tape is used on bats, and rubber handles are put on certain tools. Why does a baseball batter pick up soil and rub his hands with it before he steps into the batter's box?

Ask children to imagine what would happen if all friction were to disappear. Have them express their ideas on this subject through the use of words or pictures.

- *Friction helps us in many ways.*
- *Sand or ashes on a roadway or sidewalk increase friction and decrease slipping.*
- *More friction makes it easier to grip and turn things with our hands.*
- *Friction helps bring moving objects to a stop.*
- *Friction helps objects start moving.*

8. What else does friction do?

In addition to affecting motion, friction also causes surfaces to wear down, to make sounds, and to heat up.

Every child can examine and even measure the amount of wear on the rubber heels of shoes. Other things that wear away are automobile tires, roller-skate wheels, machine parts, stone steps in buildings, and parts of clothing. Observe and possibly measure the wear.

Friction often causes sounds such as those made by screeching brakes and tires when an automobile starts or stops suddenly, and those made when a bow is drawn across a violin string. Another result of friction is the production of heat. Have children rub their hands together briskly for a length of time and note the results. Try rubbing an eraser on a piece of paper many times, and feel the heat produced (place the eraser on

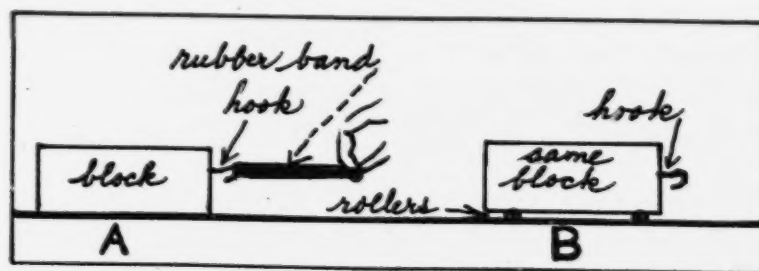
the cheek or hand). Parts of automobiles and other machines are greased and oiled to reduce friction and prevent overheating.

- Friction produces heat.
- Friction produces wear.
- Friction produces noise.

EVALUATIVE ACTIVITIES

1. In A, a block is pulled along the top of a table. In B, the same block is placed on rollers and pulled.

Draw the rubber band for the block in B as it should look like when the block is pulled (Shorter.) Why does the rubber band look different? (Easier to pull a block on rollers than one not on rollers; the rubber band does not stretch as much because there is less pull needed.)

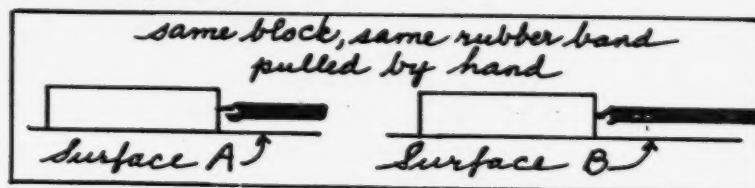


2. On which of the following surfaces would a large block of wood slide easily?

Write E for *easily* and NE for *not easily*.

- | | |
|-----------------------------|-------------------------------|
| Ice (E.) | Waxed floor (E.) |
| Rough sandpaper (NE.) | Sharp stones (NE.) |
| Blanket (NE.) | Oil on the ground (E.) |
| Soft earth (NE.) | Rubber mat (NE.) |
| Many round beads (E.) | Polished furniture (E.) |

3. In which picture below is the friction greater? (Surface B.) How do you know? (Rubber band stretches more. Rubber band shows that you are pulling harder. Friction is greater.)



4. List three places where friction is helpful. (Opening jars; using brakes; walking on ice; using an eraser; playing a violin, etc.)

List three places where friction is wasteful. (Makes door hinges "squeaky"; makes locks hard to open; makes it hard to push a heavy box, etc.)

5. In what ways can we reduce friction? (Oiling, waxing, sandpapering, smoothing, planing, etc.)
6. In each of the following, do children use their knowledge of friction in the explanation?
 - a. Why does sandpapering a block of wood reduce friction? (Sandpaper takes off the bumps which cause friction.)
 - b. Why does oiling reduce friction? (Oil falls in the spaces between the bumps and makes the surface smoother.)
 - c. Why does a match light when it is rubbed on sandpaper? (Rubbing makes friction; friction makes heat; heat makes the match catch fire.)
 - d. Why do heels have to be changed often? (Walking on the ground makes friction—friction wears off heels.)
 - e. Why do the sleeves of sweaters get holes in the elbows? (It is the place that gets rubbed the most; friction wears off the material.)
7. Ask the class to imagine a world in which there is no friction. List on the board, or have each child list on a sheet of paper, the unusual events which might take place. Some children may wish to make drawings to illustrate the events listed. Discuss the reasons for these effects. Some of them might be listed as follows. "You could slide forever." "You couldn't twist open the screwtop of a jar." "Your bicycle brakes would not work." "Autos would slip and slide all the time." "Trains would not be able to start or stop."

B. GRAVITY AFFECTS MOTION

Background for the Teacher

Because gravity is always with us we overlook its influence. It was Newton's genius which made him question the "simple" event of an apple falling from a tree to the earth.

The apple falls because the earth exerts a force, called gravity, on all objects. Raindrops, snowflakes, loose pebbles on hills, water in streams and lake, people diving and parachuting, are all pulled down to the earth.

The concept "down" bears investigation. "Down" feels and looks the same to people in New York, Tokyo, Sidney, and Nome. An astronaut, however, viewing the earth from distant space would observe that falling

objects in each of these places, although they do not move in the same direction from his viewpoint, do have one thing in common: they all plummet toward the center of the earth. "Down," then, means toward the center of the earth; "up" means in a direction opposite to the center of the earth.

When we toss a ball straight up we are opposing the force of gravity with another force originating in our muscles. As the ball moves up, gravity slows it down more and more, until it stops; then gravity causes it to fall, faster and faster.

It has been said that Galileo demonstrated, by dropping objects from the *Leaning Tower* of Pisa, that heavy and light objects fall to the earth at the same speed. Consequently, they reach the earth at the same time. (A feather will fall more slowly than a pebble because of air resistance; in a vacuum, however, both will fall at the same speed.)

In our space age we have succeeded in "tossing" space vehicles out and away from the earth by making them travel at great speed. In our Venus and Mars thrusts these vehicles have come under the influence of the sun's gravity, and are now orbiting the sun.

This leads us to the consideration that gravity is a *universal* phenomenon, not just a characteristic of Earth. Newton stated that every object in the universe—an apple, a planet, a star—attracts every other object. The *amount* of gravitational pull between two objects depends on their masses (the quantity of matter the objects contain) and the distance between the objects. The greater the masses, the greater the gravitational pull between them. The shorter the distance between the two objects (actually between the centers of their respective masses), the greater the gravitational pull.

The gravitational pull that the earth exerts on an object at any given place is called *weight* of that object. The moon, with less mass than the earth, does not exert as much gravitational pull; therefore, an apple would weigh less on the moon (only about 1/6 as much).

Approaches and Learnings for the Child

Children are asked to review their own experiences with *up* and *down* movements from the standpoint of gravity. They begin to understand why a force is needed to throw something up. They suspend a weight on a string and understand that this plumb line (plumb means vertical) points to the center of the earth. They think of children all over the earth doing this and understand the meaning of *up* and *down* on a globe such as Earth. Their experiences with throwing balls into the air suggest the nature of the problem of launching vehicles into space.

From the activities suggested, children learn the following.

Going up means going away from the center of the earth.

Going down means going toward the center of the earth.

The earth's gravity is its pull on all objects.

Objects going up are slowed by the pull of gravity.

Objects going down are speeded by the pull of gravity.

1. What goes up?

Children may suggest things go up, such as kites, airplanes, rockets, balloons, balls, elevators, and escalators.

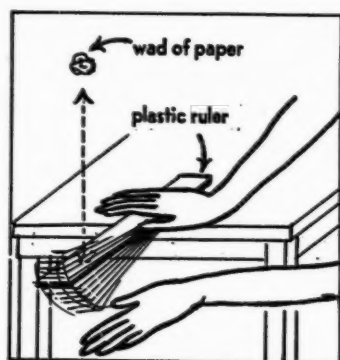
Encourage the class to include some of the less obvious upward movements such as climbing stairs, raising legs and arms, lifting shovelful of earth, walking, and swinging.

The children should understand that there are many ways of going up. They should be given the opportunity to express their ideas on the subject. Encourage them to make unusual suggestions and to explain them to their classmates. Where possible, have children perform some of these "going-up" activities.

- *Many objects go up.*

2. What makes it go up?

The children should make many objects go up in the air and use different means to do this. The most obvious method is to use the muscles of the arm or leg to throw or kick something up. Electric motors pull up elevators. Baseball bats hit fly balls. Propellers pull up helicopters.



A simple catapult.

Ask the children to use their imaginations to invent simple devices to move objects up. A ruler projecting partly over the table edge can be used like a catapult to snap a piece of crumpled paper upwards.

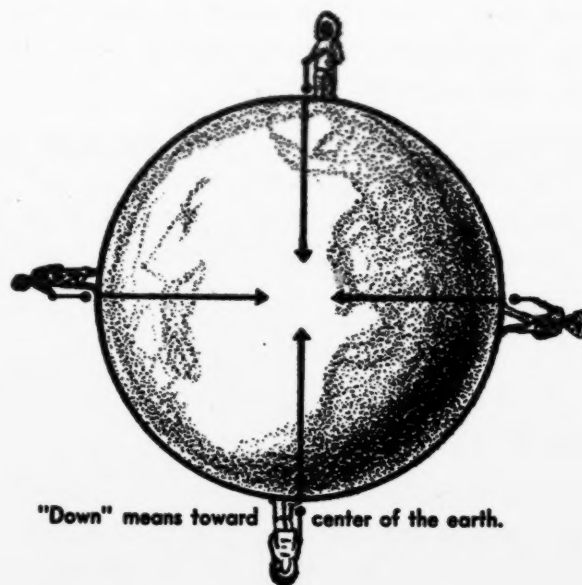
In all cases, have the children explain or identify the force which makes the object go up.

- *There are many ways to make objects go up.*

3. What is up? What is down?

Hang a small weight from a string about five feet long. This is a *plumb line*. It points to the center of the earth. Its direction is *vertical*. Find out from the students for what purpose this tool is used and by what workers. A few of these are bricklayers, carpenters, and paperhangers. It should be evident to the children at this stage that *down* means toward the center of the earth, and that *up* means away from the center of the earth. This is true all over the world. People in Australia are standing *up* even though they are on the other side of the earth.

- UP means away from the center of the earth.
- DOWN means toward the center of the earth.
- A plumb line points toward the center of the earth.



4. What comes down?

Ask the children to think of all the things which come down. Coming down means coming "toward" the earth. They may suggest rain, snow, and hail. Airplanes eventually come to earth. Escalators and elevators which go up also come down.

Through discussion establish the point that, except for certain rockets and satellites, things that go up must come down.

- Things that go up also come down.

5. What makes it come down?

Have each child hold a coin or other small object between his fingers. Ask, 'What will happen when you let go of that?' When the children

predict that the objects will fall, inquire, 'Why does this happen?' The children should be led to conclude that there is an invisible force that pulls on all objects.

This pull is called *gravity*. It always pulls straight down toward the center of the earth.



Hold out the weight (which was constructed for *Problem 3*, page 128) so that it swings freely. The weight pulls the string into a vertical (straight up and down) position. Why does this happen? The children should realize that the string points toward the center of the earth; the earth pulls in that direction on the weight.

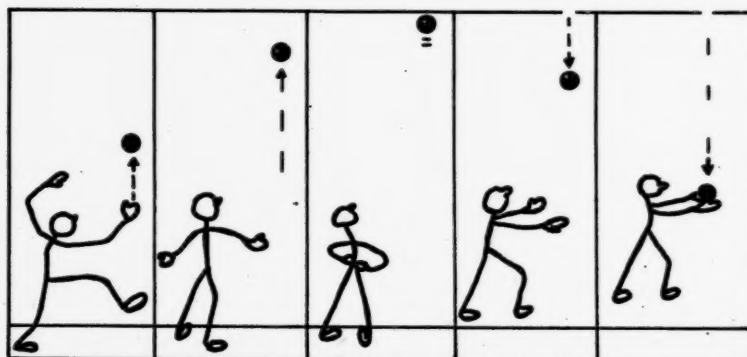
Use this plumb line to determine if the sides of furniture, buildings, and poles are vertical.

Arrange a long surface (plank of wood, large book, table top) so that it is on a slant. Have the children place different objects at the top of the incline and notice how they move down. In each case, gravity pulls the object down the incline.

- *Objects fall to earth because gravity pulls them down.*

6. How high can you throw a ball?

This activity can be carried out in modified form in the classroom, but it is best performed in the school playground. A ball is thrown up in the air. The children are asked to watch its progress carefully, and to report what they see. They notice that the ball moves up, gradually slowing until it comes to a stop. Then it falls back to earth. Discuss this series of events.



A ball goes up . . . stops . . . comes down.

The children should understand that while the ball goes up it moves against gravity. The force of the arm muscles is great enough to cause the ball to rise against the pull of gravity. Because of gravity, however, the ball keeps losing speed and finally stops. Gravity then pulls it down to earth.

Have two children toss balls up at the same time. Compare the heights reached by the balls. Pupils will observe that the stronger thrower tosses the ball harder. It moves faster and higher against the pull of gravity.

- *The faster a ball is thrown up, the higher it goes.*
- *A ball thrown upward rises, stops, and falls back to earth.*
- *Gravity pulls a ball back to earth.*

7. Why can't a baseball player bat a ball "out of this world?"

Is it possible for a baseball player to bat a ball so high that it will never come back to earth? The children will probably say that this is unheard of. It is indeed impossible. No human being can hit a ball with enough force to make it leave the earth forever.

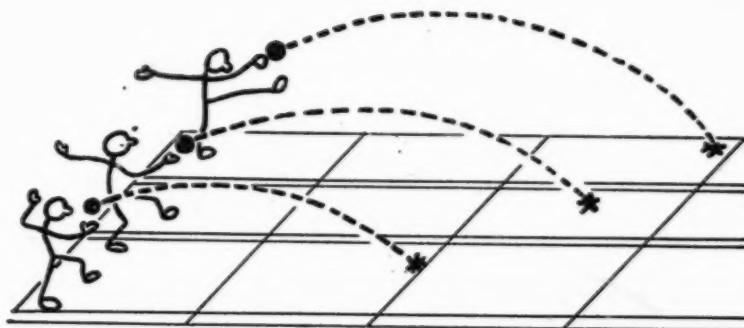
At this point ask the children whether any object was ever sent off the ground fast enough to leave the earth forever despite the pull of gravity. The answer, of course, is "Yes." Rockets can go "out of this world" if they are shot up fast enough.

The pull of gravity can be compared to the invisible force with which a magnet pulls on iron objects near it. (In this comparison, point out that gravity pulls on everything, not only on iron.) The farther away an object gets from a magnet, the weaker the attraction; the farther away an object gets from the earth, the weaker the earth's pull on that object.

- *A person cannot hit a ball with enough force to make the ball leave the earth forever.*
- *Rockets can leave the earth forever, if they move fast enough.*

8. How far can you throw a ball?

In the playground, have one child throw a ball gently while the others watch. Mark the spot where the ball strikes the ground. Ask him to throw the ball harder. Mark the more distant point where the ball strikes the ground. Finally, have him throw it as hard as possible. Again mark the spot where the ball falls.



Greater force . . . greater speed . . . greater distance.

Ask the children to discuss their observations and conclusions. They should recognize that the harder the ball was thrown the farther it went. Gravity pulls on a thrown ball the instant it leaves the hand. However, the faster-moving ball can travel a greater distance before gravity pulls it down to earth.

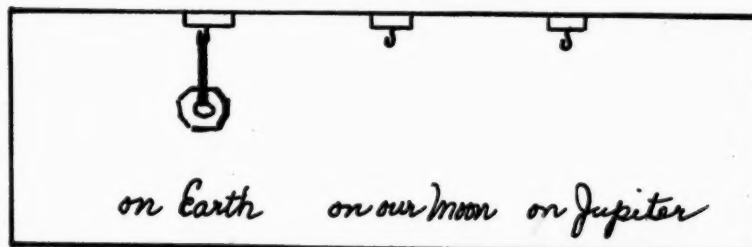
- Gravity pulls down every thrown ball.
- Fast-moving balls travel farther before they fall back to earth.

EVALUATIVE ACTIVITIES

1. Ask the children to imagine themselves as astronauts who have landed on a small planet on which the force of gravity is much less than that on Earth. Discuss the unusual happenings they might see and feel.

Make a list on the board, or have each student write his own list, and offer explanations for his answers. Some children may wish to make sketches to illustrate their answers. (It is easier to jump up; you can jump higher; you can throw a ball higher; you can jump off a cliff and land safely; you can move large rocks easily.)

2. The pull of gravity on the moon is less than that on Earth. The weight shown in the following illustration is hanging from a rubber band on Earth. Draw it as you think it would look on the moon. (Shorter stretch.) The pull of gravity on Jupiter is much greater than that of Earth. Show how the hanging weight would look on Jupiter. (Longer stretch.)



3. The following words will help you complete the sentences listed below.

up	down
gravity	longer
earth	

- a. Going means going away from the earth. (Up.)
 - b. A baseball cannot be hit with a bat so that it lands a mile away because pulls it to the earth. (Gravity.)
 - c. The pull of the on all objects is called gravity. Earth.)
 - d. Objects going are slowed by the pull of gravity. (Up.)
 - e. Objects going are speeded up by the pull of gravity. (Down.)
 - f. A fast-moving ball will travel a distance before it falls to the earth than a slower-moving ball will travel. (Longer.)
4. In the following sentences write H where gravity *helps* us, and N where gravity is somewhat of a *nuisance*. In each case, explain why. (Do children use the concept of gravity in their explanation?)
- Our homes do not shake too much in a wind. (H. Gravity holds them on the ground.)
- Rain falls on farmers' crops. (H. Gravity makes rain fall down from the clouds.)
- We must often hold heavy packages in our arms. (N. Gravity makes them heavy.)
- We walk up hills or stairs. (N. Gravity makes our bodies heavy; we have to lift our bodies against the pull of gravity.)
- Cartons have to be lifted to a truck. (N. Gravity makes them heavy; we have to lift against the pull of gravity.)
- A weight at the end of a string pulls it down. (H. Gravity pulls the weight and the line straight toward the center of the earth.)
- Water can be poured from a kettle. (H. Gravity makes it go down out of the spout.)
- Rockets are sent into space. (N. Earth's gravity pulls against the rockets and slows them down.)
- People walk down stairs. (H. Gravity pulls down and makes it easy to walk down.)

**BASIC SUPPLY LIST
FOR FRICTION, GRAVITY, AND MOTION**

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- | | |
|--------------------|------------------------------|
| 1 Spring Scale | *1 pkg. Paraffin Wax |
| 1 Magnifying Glass | *1 jar Vaseline (Petrolatum) |
| | *5 lbs. Sand |

G-1: General Supply List

- | | | |
|------------------|-----------------------|--------------------------|
| 2 Pencils, round | *1 ball of String | *1 pkg. Absorbent Cotton |
| 1 Rubber Band | (warp, thread, white) | 4 sheets of Composition |
| 2 Nails, 1" | 1 sheet of Sandpaper | Paper |
| 2 Hand Balls | 1 Ruler, 12" | |

Miscellaneous:

- | | |
|-------------------------------|-----------------------------|
| 3 blocks of Wood 1" x 2" x 8" | 1 piece rough Cloth |
| 1 wooden Plank 1" x 4" x 4' | 12" x 12" |
| *1 sheet Corrugated Paper | *1 roll Friction Tape |
| *1 bar of Soap | 4 Coins |
| *1 can Machine Oil | 4 empty Spools (equal size) |
| *1 pail Ashes | 2 Knitting Needles |
| 1 twist-off lid from food jar | 1 pair Roller Skates |
| | 2 Jar Tops |
| | 20 Marbles |



Rocks and How We Use Them

A. ROCKS WE USE

Background for the Teacher

The story of the earth is written in the rocks used in or near the school. Children who live in the city can be introduced to the study of rocks through first-hand experiences with materials found in the vicinity, as well as through visits to outcroppings of rock in the parks.

The cement in the sidewalks, the bricks of the chimney, the glass in the windows, the porcelain sink, the ceramic tile and the plaster of the walls and ceilings, all come from rock. Man adds other chemicals to the clay, sand and limestone derived from rock, and produces many building materials to fit his needs. Concrete is one example of man's use of nature's raw materials. Cement is a fine, soft, powdery substance made from limestone and clay. When it is mixed with sand, water, and pebbles, it becomes the strong, hard concrete used for building roads, bridges, and houses.

It is significant, however, that even today, with modern, economical and easily handled building materials at their disposal, builders still use many of the same natural rocks used by primitive peoples. This is not surprising since many of these rocks are plentiful, durable, and extremely beautiful. These characteristics of natural stone are often sufficient to outweigh difficulties in cutting and transporting it.

The rocks of the earth's crust may be divided into three large groups, according to the way in which they were formed: igneous rocks, sedimentary rocks, and metamorphic rocks.

IGNEOUS ROCK is formed as a result of cooling and hardening of hot molten rock (magma) from within the earth's crust. Volcanoes are a source of igneous rock. Some examples of igneous rocks are obsidian, pumice, and granite.

Obsidian (sometimes called volcanic glass) results from the rapid cooling of surface lava. It was once used to make arrowheads and knives.

Pumice, used in many scouring powders, contains holes which were formed by escaping gases while the rock was still liquid. Some pumice is so light it will float on water. Granite is recognized by its speckled appearance. It is very heavy and durable. It is a popular building stone and is often found in statues.

SEDIMENTARY ROCK is characterized by a banded, layered appearance due to the different kinds of materials that were deposited, one on top of another, while the rock was forming. These rocks are built up under water by the depositing of sediments (sand, clay, mud, pebbles, or gravel) or plant and animal remains such as ferns or shells. The pressure of the accumulating materials slowly forces the lower layers of sediment to harden into rock.

Many sedimentary rocks are easy to identify. Sometimes the grains of sand in sandstone are very loose and can be dislodged by rubbing two pieces of this rock together. The outside walls of public buildings often may be made of this rock. Another example of an easily-identified rock is shale, which smells like mud when it is wet. Limestone can sometimes be identified by the plant and animals impressions (fossils) found in it.

METAMORPHIC ROCK is formed when the physical and chemical properties of rock have been changed by heat as well as pressure. The heat may come from the friction of moving layers or from the proximity of hot magma. The pressure may result from large movements of the earth's crust that crumple and fold layers together. Originally, tiny animal skeletons and seashells were compressed at the bottom of the sea, becoming soft limestone. This sedimentary limestone was squeezed still more, and also heated by the proximity of magma. The pressure and heat melted and fused the limestone into what we call marble. The color of marble depends on the color of the sediment from which it was originally formed. Other examples of metamorphic rock are gneiss and schist. The three basic rock formations underlying Manhattan and the Bronx are Fordham gneiss, Inwood marble, and Manhattan schist, all metamorphic rocks.

The curriculum bulletin, *Operation New York*, available in each school, is a rich source of information about the man-made and natural rocks in the New York City area. It also provides many suggestions for trips and investigations which may be used to supplement the activities which follow.

Approaches and Learnings for the Child

Curiosity about rocks may be aroused in children by calling their attention to the everyday use of rocks. In an introductory "hunt," children

see that rocks are used in many places in and around their school. They learn that some of these rocks occur in nature and that others are made by man.

Investigation of the properties of many different rocks, both natural and man-made, helps children learn how to examine and identify various kinds, and leads them to understand why each is used in a special way.

These investigations also provide them with opportunities to employ such science processes as observing, classifying, and making inferences. By placing emphasis on these skills rather than on rote memorization of rock names, the children are given tools for future explorations.

In studying man-made rocks, children prepare several varieties such as concrete, brick, and plaster in their classroom. Through reading, they learn how others, such as glass, tile, and terrazzo are made.

Following their study of the properties and uses of many rocks, the children go on a "hunt," in which they repeat their introductory tour of the school. This time they are able to recognize and identify the various materials they see, and can understand why each is used as it is.

From the activities suggested, children learn the following.

Rocks, both natural and man-made, are used for building materials.

Rocks are used because they are strong, resistant to fire and water, easily shaped, durable, available, and beautiful.

Different rocks have different properties and different uses.

Rocks can be identified by their general appearance and by using simple tests.

1. Where is rock used around the school?

Go on a "hunt" for rocks, natural and man-made, in and around the school. In the classroom, children might notice the chalkboards, window sills, and sink. In the school, they might find steps, walls, and floors made of rock. Outside the school, they will probably see walls, foundations, sidewalks, and curbs.

After the trip, discuss with children why rocks are used so extensively in building. Help them list the qualities building materials should have.

These qualities might include strength, durability, water resistance, resistance to burning, resistance to rust, beauty. Ask whether rocks have these qualities.



Hunting for rock in the school building.

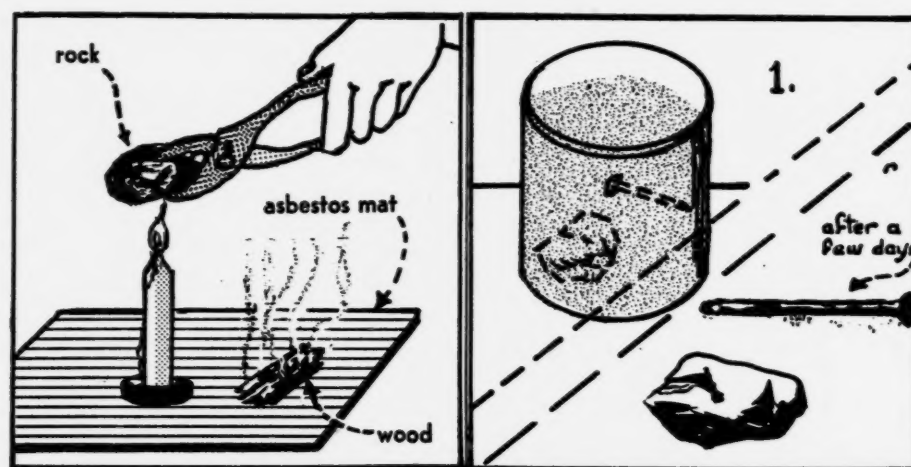
Have children suggest ways of testing their answers. Let them try their tests and record their findings on a chart.

Some of their tests might include:

Strength. Put a pebble under each corner of a heavy stack of books. Are the pebbles crushed? Wrap a pebble in a cloth and strike it with a hammer. What happens? Compare with what happens to a wooden head similarly treated.

Water resistance. Place a rock on a piece of wood in water so that the wood remains submerged. After several days, wipe dry. Crack the rock in a piece of heavy cloth with a hammer. Cut or split the wood open. Has the water seeped in? Is there any evidence of warping?

Wear. Scratch different pieces of stone and a piece of wood with a knife or pen point. Which is scratched more?



Rocks do not burn. Rocks do not rust.

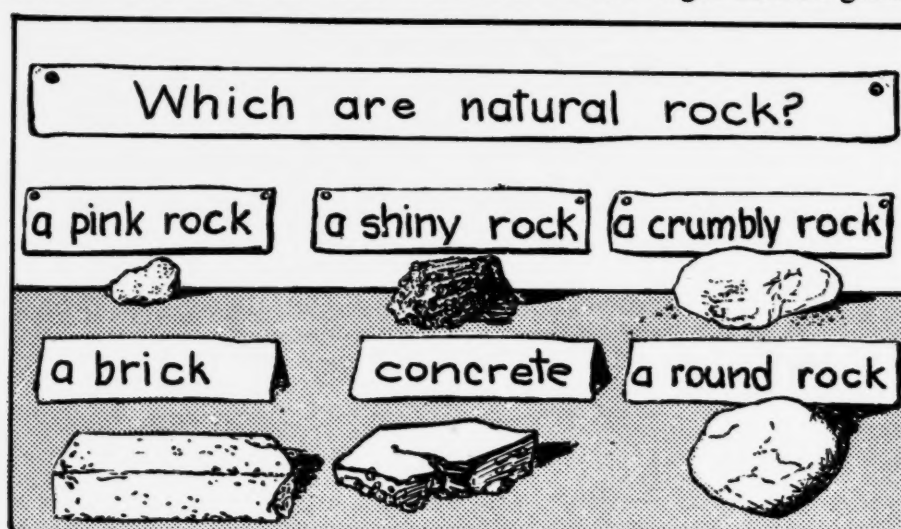
Burning. This test should be done by the teacher. Hold a piece of wood and then a rock over a candle. (Take all safety precautions necessary when working with fire.) Which burns? Which is charred?

Rusting. Put some pebbles and some iron nails in a jar of water or moist soil. Observe both after a few days. *Note:* Some rocks which contain iron may show evidence of rust.

- *Rock is used in many places in and around the school.*
- *Rock is used in buildings because it is strong, does not rust, does not get wet inside, wears away slowly, and does not burn.*

2. Which of the rocks around our school are natural rocks?

Display samples of rocks, using several which occur naturally and several which are man-made. The natural rocks might include granite,



slate, marble, limestone, and sandstone. These can usually be obtained from the school science closet or on loan from children's personal collections. The man-made rocks might include brick, cinder block, tile and porcelain. Samples of these may be obtained from local builders; fragments are often found in vacant lots.

Ask the children to express their opinions about which of these specimens were found in nature, and which were made by man. Have them discuss the reasons for their answers. They might mention the uniformity in shape, texture, and composition of the man-made rocks. In some cases they might encounter some difficulty. For example, it is sometimes hard to distinguish pieces of concrete from the natural rock, *conglomerate*.

Discuss other man-made rocks with which the children are familiar. Encourage them to describe experiences they may have had seeing concrete or other rocks being made.

If there is an excavation in process nearby, children may be able to see natural rock on its natural site. The curriculum bulletin *Operation New York* describes the three basic rock formations underlying a good part of the New York City area: Manhattan schist, Fordham gneiss and Inwood marble. In some areas of the city, in parks, roadcuts, and hills, these kinds of bedrocks are at the surface and may be viewed at any time. For example, in Central Park there are many large outcroppings of Manhattan schist. Plan a trip to one of these areas.

- *Some rocks are natural.*
- *Some rocks are man-made.*
- *There is natural rock under New York City.*

3. How can we tell one natural rock from another?

The purpose of this problem is to encourage children to *devise* methods of distinguishing different kinds of rocks. As they use the criteria they suggest, they begin to distinguish between the significant characteristics of rock (color, texture, graininess, hardness) and the less important, accidental characteristics, such as size and shape.

Assign a number to each of the natural rocks grouped together in *Problem 2*. Ask the children to examine these rocks and to suggest how they would describe each specimen. They might mention such characteristics as size, shape, texture, color, luster, layers, weight, and conspicuousness of grain. Provide children with magnifying glasses to aid their investigations.

If size and shape were mentioned lead children to understand that these terms may describe the particular rock they examined, but are not characteristics of the type of rock. Remind children that they should use rocks of the same size when comparing weight; also, that the colors of the same kind of rocks may vary considerably.

Have children prepare a chart in their notebooks and on a large sheet of oaktag to be displayed on a bulletin board. On these charts children can keep a record of their observations. Leave several blank columns for other properties children might want to add later.

Through discussion, guide children to note that all of their observations have been based on the appearance and "feel" of the rocks. Ask them to suggest other ways they might want to examine the rocks. Some might want to rub two rocks together to see if they can make sand. Others might want to find out how hard each rock is by trying to scratch one with another. Some might try splitting apart the apparent layers of a rock. Others might want to see whether rocks float or sink in water. You may want to suggest that the children try an acid test. To perform this test, hammer a small piece of the rock between a cloth until it is powdered. Place the material on a plate. Then pour a little strong vinegar or prepared lemon juice on the powdered rock. Some rocks "fizz" when this test is performed.

Some of these observations can be added to the blank columns on the children's charts.

<i>Rock</i>	<i>Color</i>	<i>Texture</i>	<i>Luster</i>	<i>Grains</i>	<i>Layers</i>	<i>Hardness</i>	<i>Acid Test</i>
#1	grayish	smooth	dull	seen none	yes	very soft: scratched by #2,	does not fizz
#2	black	smooth	glassy	seen	no	#3, #4.	does not fizz
#3							

With the help of books on rocks (see *Bibliography*), children may take tentative tries at naming the rock specimens. Comparison with rocks in commercial collections will be helpful (see *E-1 List*).

- *Rocks are different in color texture, size of grain, shininess.*
- *Some rocks are harder than others.*
- *Some rocks "fizz" when acid is poured on them.*
- *We can tell what kind of a rock we have by its characteristics.*

4. What can we find out about the natural rocks used around our school?

Through discussion, help the children to formulate a list of the things they would like to find out about natural rocks used around the school.

Their list of questions might include the following.

What natural rocks are used around the building?

Why is each of these rocks used as it is?

How can we recognize each of these rocks?

Where do these rocks come from?

The children may be aware of many of the rocks that are commonly used. They may have read in periodicals about the use of marble in the U.N. building, of granite in monuments, of limestone for window sills and building fronts, and of slate for blackboards. If they do not mention such other frequently used rocks as bluestone, brownstone or gray sandstone (all of these are sandstones) you might suggest that they be added to the children's list.

Obtain from the science closet as many samples as possible of each of the rocks listed above. Each of these specimens will be labeled with a number, which can be matched against the names of the rocks printed on the cover of the box.

The children will enjoy and profit from their investigations and derive more from them if they do not see the names until they have made their own identification, based on the kinds of observations made in *Problem 3*.

Because of children's familiarity with the chalkboard, begin by studying slate. (In newer schools, chalkboards may not be made of slate.) Ask why slate is used for chalkboards. Children's answers might include the observations that chalk is easily seen against its color, that it washes or erases easily, and that it takes chalk marks well. Lead them to see that the reason we can write on it is that it is smooth, but not too highly polished. They might want to try writing on a highly polished surface, such as glass, and on a rock that does not have a flat surface.

Encourage children to make as many discoveries as they can about the appearance and other characteristics of slate, and to enter their findings on a chart. This investigation can be followed by similar studies of each of the other common rocks on their list. All of the findings should be entered in their notebooks and on an oaktag chart. When they have learned as much as they can about each specimen,

they may want to identify them by name by using books about rocks. They will enjoy matching the names they chose against the names of the rocks as listed on the cover of the box from which they came.

The charts prepared by the children might contain some of the following information.

ROCK	*GENERAL APPEARANCE	(YES=CAN BE SPLIT INTO SHEETS)	HARDNESS	ACID TEST
Slate	dark gray; cannot see grains; slight luster	yes	harder than shale	does not fizz
Marble	white, colored, or mottled; shiny; cannot see grains	no	softer than granite	fizzes
Granite	grayish or light color with black grains and specks of shiny mica	no	very hard: scratches most other rocks	does not fizz
Limestone	whitish-grayish; contains shells; very fine grains	no	softer than granite	fizzes
Sandstone	yellowish-brownish; contains grains of sand	no	easily scratched	does not fizz

*The color and luster of different specimens of the same kind of rock may vary.

When the children's investigations have been completed, discuss with them how significant some characteristics of the different specimens are in respect to their use as building materials. Guide the children to see, for example, that granite, because it is so hard, will wear away slowly and therefore is an excellent rock for surfaces which will receive a great deal of wear. However, because it is so hard, it is difficult to shape. When durability is not important, it might be better to use a softer rock, such as limestone or sandstone.

GRADE THREE

Committees may do research concerning where and how some of the rocks are quarried. Some children may have visited granite or marble quarries in Vermont during a vacation, and might share their experiences with their classmates.

- *Some natural rocks used around the school are slate, granite, marble, limestone, and sandstone. (The dark-gray, fine-grained stone used for steps inside schools is sandstone.)*
- *Different rocks are used for different purposes, depending upon the rocks' properties.*
- *Slate is used for chalkboards because it takes chalk well, cleans easily, and lasts a long time.*
- *Granite is used for curbstones, in monuments, and in buildings because it is very hard and long-lasting.*
- *Limestone and sandstone are softer than marble.*
- *Marble is beautiful. It is harder than limestone and sandstone, but softer than granite.*

5. Which man-made rocks are used around the school?

Recall the discussion of man-made and natural rocks in *Problem 2*. Ask children to bring samples, from home or the neighborhood, of different kinds of man-made rocks, and to report briefly on where they were found and how they were used.

The children may like to make a model or a sketch of a building, placing each specimen where it might be used.

- *Many different man-made rocks are used in buildings.*

6. Where do the bricks in our school come from?

To find out what is used to make bricks, take a small piece of brick out into the schoolyard and crush it. The piece of brick should be placed inside a heavy-duty paper bag or cloth bag, and struck with a hammer until it is crushed into a powder. Children will see that brick is made of a powdery substance which, when moistened, can be modelled into the shape of a brick again.

Ask children to read and report on brickmaking. Brick is a construction material made of clay (a kind of rock) mixed with water, shaped into a block, and allowed to dry. After this, bricks are baked (or burned) at very high temperatures.

- Bricks are made of clay, which comes from the earth.
- Clay is mixed with water, shaped, dried, and then heated to make it long-lasting and resistant to water (rain).

7. How can we make our own bricks?

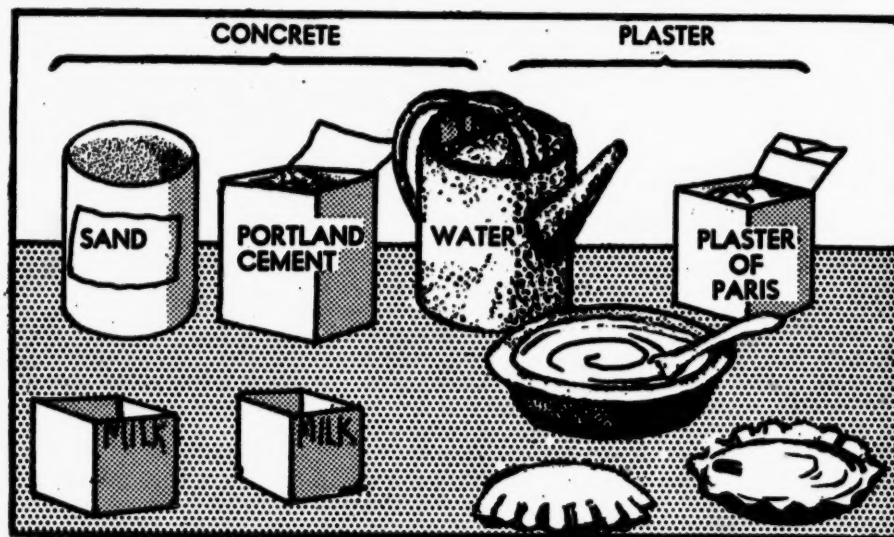
Have children shape some wet clay into bricks by pressing it into a small milk container or other box. Allow to dry. Compare with standard bricks for hardness (scratch it), for strength (strike it with a hammer), for resistance to water (wet it), for crushing (stand on it). What step was omitted by the children in the making of their bricks? Bricks must be hardened by heating them to high temperatures, in furnaces or kilns.

In parts of Mexico and other places where the heat of the sun is fierce and it seldom rains, *adobe* homes are built of bricks made from moistened earth (clay or loam), which is mixed with a small amount of straw or grass for strength, then dried in the sun for about two weeks.

Try making bricks from concrete-mix or from plaster-of-Paris. Mix either of these materials with sufficient water to make a thick paste.

Place in molds, such as empty, clean milk containers or small boxes.

Remove the molds when the blocks have hardened.



Water + sand + cement = concrete.

Water + plaster of Paris = plaster.

GRADE THREE

- *Bricks are made to resist crushing, fire, frost, and water.*
- *In some places, moistened earth is mixed with straw or grass to make a kind of brick.*

8. Why is glass an important building material?

Find glass in such places as windows, clocks, cabinet doors, stairwells, picture frames, skylights, drinking glasses, eyeglasses, electric bulbs, globes, and vases.

Children can be motivated to learn about glass making by collecting many different glass objects. Include colored glass, optical glass, safety glass, heat-resistant glass, plate glass, fiberglass, spun glass, and others.

Children will learn that glass making is a very old craft. The basic ingredients used in making glass come from the earth as raw materials. Silica (sand), soda (sodium oxide), and lime (calcium oxide) are mixed together and melted in special ovens. Other chemicals such as lead (powdered), flint (powdered), dolomite, and ceramics may be added to the basic ingredients to color the glass and to produce stronger and more resistant glass objects.

Discuss with children the unique characteristics of glass which make it so useful. They may suggest some of the following reasons.

You can see through it.

It doesn't scratch easily.

It can be made into many shapes.

It doesn't burn or rot.

It is easy to clean.

It holds water.

- *Glass is used in many ways in our building.*
- *Sand and other materials are used in making glass.*
- *Heat resistant glass is made by adding special chemicals.*

9. What are the walls and ceilings of our classrooms made of?

Have children look closely at the walls and ceilings in the room and elsewhere in the school building to see what they are made of. Chipped or peeled wall surfaces will reveal a white, easily scratched material. Ask children what this is called. (Plaster.) Plaster is made from a very soft rock called gypsum. Raw gypsum contains a great deal of

water. The gypsum is heated to remove most of the water. The fine white powder which results is called plaster-of-Paris. This plaster hardens quickly after it is mixed with water and then exposed to air.

Have children mix a small amount of plaster-of-Paris with water until the mixture is creamy. Then pour the mixture into a small, clean milk container. Allow the mixture to harden overnight. Remove the milk-container mold and let children examine the hardened plaster cast. Does plaster scratch easily? Try marking it with a fingernail.

- *Ceilings and walls are often made of plaster.*
- *Plaster is made from a rock called gypsum.*

10. Where have you seen ceramic tile in our building?

Have children recall where ceramic tile is used in the school; then take a walk to verify the places they named, and to find others. Ask them to find out where there is ceramic tile in their homes.

Ask children to bring pieces of ceramic tile to school. Have them notice the variety of sizes, shapes, colors, and textures that tiles may take. Try scratching tile with a penny.

Why are ceramic tiles usually found on bathroom floors? Where else is ceramic tile found? Children may recall seeing it in cafeterias, kitchens, hospitals, laboratories, and clinics. Many schools also have tile on corridor halls and in basements.

Tile (ceramic) is made of baked clay. Many different kinds of clay can be used. Children may be reminded that clay is a rock found in the earth. To produce the shiny, glasslike surfaces of most tiles, a glazing (glass forming) compound is applied before baking the tiles in an oven (kiln). The glaze itself also comes from rocks and minerals found in the earth.

- *Tile is made of clay which has been glazed and baked.*
- *Tile comes in many colors.*
- *Glazing produces the glasslike finish on ceramic materials.*
- *Tile floors and walls are easier to keep clean than painted floors and walls.*
- *Tile is waterproof.*
- *Tile is not easily scratched.*

11. What is the entrance hall floor in our school made of?

The entrance halls of many schools have colorful floors made of *terrazzo*. Terrazzo floors contain chips of colored marble embedded in cement. After the chips are laid in the cement, a grinding and polishing (rouging) machine is used to produce the smooth, shiny surface. Terrazzo floors, which were made famous in Italy's churches, are now found in most of our new public buildings, apartment houses, and office buildings. Terrazzo is expensive, but easy to maintain, durable, and handsome.

Take the class to the entrance hall to examine the floor. (Magnifying glasses will assist children to observe closely.) If it is made of terrazzo, ask questions such as the following to encourage careful observation. What is in the floor? (Chips of colored marble.) Are they all the same size and color? (No.) How many colors can you see? Are the borders different from the main part of the floor? (Usually.) Why are thin strips of metal embedded in the floor? (Aluminum or brass strips are used to separate differently colored shapes and designs. These strips also serve a practical purpose: they prevent small cracks from spreading. Ask children to find places where cracks have been stopped.)

- *Terrazzo is made of colored chips of marble embedded in cement.*

12. How are sidewalks made?

Watch a sidewalk being laid or repaired. Note how the concrete is mixed and poured. Make concrete in the classroom by mixing cement, sand, and water. A sand mix gives a fine, even-grained consistency. To strengthen the mix, use gravel instead of sand. A gravel mix gives a coarser, heavier, and sturdier mix.

To make a sand mix use the following ingredients. Measure three level tablespoons of cement into the bottom half of an empty milk carton. Make a ditch in the middle of the cement and measure one tablespoonful of water into it. Now use a spoon to mix the cement with the water. Add one more tablespoonful of water and mix again. Now you are ready to add the sand. The exact amount depends upon how thick the mixture gets. The mixture should not be watery, but the consistency of cooked oatmeal. Pour the concrete into a wooden box such as a cigar box, or into a milk container.

Set the resulting block aside until it is hard. After a week or so compare it to the sidewalk outside the school for hardness and strength by scratching and striking.

Note that sidewalks have curbs made of granite or reinforced concrete. The curb has to be particularly strong, since the edge is hit often by the rims of car wheels.

- *Sidewalks are often made of strong, hard materials such as concrete.*
- *Concrete is a man-made stone.*
- *Concrete can be shaped by pouring it into a form.*

13. How do builders make a street?

Take a walk around the neighborhood to find out how many different kinds of roads and streets there are. Children may see or know about streets made of such materials as macadam (asphalt and stone chips), concrete, cobblestones, crushed rock, sea shells, soil, and even wood. What is the advantage of hard roads over soft ones? Explore a street that is being widened and repaved. Keep a record of the techniques used, steps taken, and progress made. Note the materials and machines used.

- *Many materials are used to pave streets.*

14. How can we go rock hunting?

Children are now ready for a second trip to explore the school and its surroundings for natural and man-made rocks, and to identify those they find. One product of this activity may be a "field" guide of the school, with stops in sequential order, duplicated for the use of other teachers and children. With this field trip as a basis the children may wish to prepare a guide for a neighborhood field trip covering a wider area.

- *There are many natural and man-made rocks in our school and neighborhood.*
- *Different rocks have different properties and uses.*

A SAMPLE FIELD TRIP

WHERE TO GO	WHAT TO SEE	REMARKS
In the classroom	Chalkboards	Chalkboards are made of slate. Slate is formed when a rock called shale is under tremendous pressure for millions of years. Slate occurs in layers in the earth. It is carefully removed by long, thin chisels. It is polished but left slightly rough so that the chalk can rub off on it. For comparison, try to write with chalk on a glass pane.
At a drinking fountain	Marble on wall behind sink	Marble is a beautiful building-stone of many colors and patterns. It is formed when limestone rock is under great pressure and heat for hundreds of centuries. It is used around the sink because it is easier to clean than a painted wall.
At a drinking fountain	Porcelain covering of sink	Porcelain is made by baking a certain kind of clay (which is really a soft rock). It has a shiny, durable glaze on it. A porcelain sink may have an inner framework of iron. Test by placing a magnet against it. Feel the underside too.
In the doorway of a boys' or girls' lavatory	Marble sill over threshold	Why do certain rooms have marble sills? Can it be that these rooms are washed more frequently, and wooden sills would rot?
In the hall	Colored tile on walls	Tile is a glazed, baked clay. (A glaze is a hard, glasslike surface.) Tile comes in many colors, is easy to clean, and resists scratches. It is called a ceramic material. A tile wall costs more than a painted plaster wall, but it lasts longer. The chemicals for glazes come from certain rocks and minerals.
In the hall or classroom	Painted, plastered walls	Plaster is made from a soft rock called gypsum. When gypsum is heated in a certain way it becomes plaster of Paris. When water is added to this it hardens. Sand is added for more strength. The chemicals used in the paint come from rocks and minerals. Children may make plaster of Paris casts using home-made molds.

A SAMPLE FIELD TRIP (continued)

WHERE TO GO	WHAT TO SEE	REMARKS
On the stairs near any exit.	Bluestone steps	The dark, bluish-gray stone used is bluestone. It is a smooth type of sandstone. It is not very hard, and heavy traffic causes wear, especially near the hand rails. Test for wear by placing a straight yardstick across the step. One can "see daylight" over a worn area. Sandstone is formed in nature when sand settles, usually under water. As the layers build up, the pressure cements the grains of sand together to form rock.
In the basement	Soapstone drinking fountain	Soapstone is a soft stone. It is cheap, easy to cut and drill so that plumbing fixtures can be attached. Soapstone has a soapy feeling. It is related to talc (used to make talcum powder). A tailor uses a kind of soapstone, for marking fabrics. It is called French chalk.
Anywhere	Glass windows	Glass is made from materials found in the earth. Sand, lime, and soda are melted together in special ovens. Look at sand grains with a magnifying glass. Do they look glassy? Are there different colors?
In the main lobby	Marble steps and walls	See the interesting, colorful patterns. Use a yardstick to test for wear in the steps. If marble is a soft material, why is it used for steps in lobbies?
In the main lobby	Terrazzo floor	Terrazzo is made of colorful chips of marble and cement. Terrazzo floors are used in cathedrals in Italy. Terrazzo is expensive but it lasts long and is very decorative. Metal strips of brass or aluminum are sometimes used to allow separation of colorful designs. They also prevent small cracks from spreading. Try to find places where a crack stopped.
Outside the main entrance	Gray stone around main doors	This is limestone. It consists of materials from sea shells and the skeletons of other ancient sea life which settled under water and were compressed into rock. Fossils can often be seen in limestone. A magnifying glass will help. Limestone is also used for window sills and around the base of the building. It looks like concrete from a distance but limestone has a smoother texture and looks better than concrete. The pyramids in Egypt are limestone.

A SAMPLE FIELD TRIP (continued)

WHERE TO GO	WHAT TO SEE	REMARKS
The front steps	Granite	Granite is very hard and long-lasting. This rock was once molten in the earth. It came to the surface by volcanic action. The children may find a shiny material in it called mica. It also contains quartz and several other minerals. It is expensive because its hardness makes it difficult to shape. It comes in many colors and grains. Cemetery monuments are made of granite. Old cemetery stones which were made of marble instead of granite are worn down and difficult to read today.
In the rear of the building	Steps, and stone at the base of the building	Bluestone is used here. Notice the scaling of the stone. The sun's heat causes the surface of the stone to expand and chip away from the layer underneath. At night the stone contracts when it cools. This, too, causes scaling. In the winter, water gets into a crack. As the water freezes it expands and chips off a layer of bluestone. The scaled pieces are often found at the base of the wall. (Freezing of water in cracks is one way mountains become worn down to sea level.)
Near the flag	Flagstone walk	Made of bluestone. Why is a flagstone walk necessary here?
At the gate in front of the building	Bluestone inserts in concrete sidewalk	The hole in the stone is to receive the end of a bar serving as a brace for the gate when it is closed. Which is harder—bluestone or concrete?
Outside the building	Sidewalk	Sidewalks are made of concrete, which is a mixture of cement, sand, and gravel. Cement is made from certain rocks and minerals. The ruled lines in concrete prevent cracks from spreading. Certain spaces between sections are filled with tar. These allow for expansion due to heat. Place a ball on the sidewalk and it will roll down the slight tilt toward the gutter. This tilt is why puddles usually do not collect. To prevent water from freezing into smooth layers, the sidewalks are finished in dimpled or rough surfaces. Look for these "anti-skid" patterns.

A SAMPLE FIELD TRIP (*continued*)

WHERE TO GO	WHAT TO SEE	REMARKS
At the edge of the sidewalk	Curbstone	Curbstones are made of concrete, bluestone or granite. Corner curbstones are usually made of granite, or reinforced with metal strips.
At the curb	Asphalt street	The street includes the sidewalk and the roadway. The middle of the roadway is the highest spot or crown. The road slants downward towards the gutter which is next to each curb. The gutter is graded along the length of the street so that water flows into a sewer. The black road material is made of asphalt and rock (bluestone) dust. Asphalt is a black material left in petroleum after gasoline, oil and other substances are boiled off. When chunks of rock are added to asphalt it is called macadam, named after a Scotch engineer, MacAdam. Asphalt is used because it never becomes very hard. It can expand and contract daily with hardly any cracking.
At a tree in front of the school	Cobblestones around the tree	Granite cobblestones were once used for streets. They are useful around trees: when the roots grow, the sidewalks are not lifted. Instead, the cobblestones are easily removed and the roots chopped lower.
A house at . . . (address)	Granite fieldstone	Granite used in this way is called fieldstone. Years ago, people used stones from cleared fields to build houses. Today, only small pieces or sections of fieldstones are used, usually for ornamental purposes.
A garage at . . . (address)	Cinder or cement wall	Cement is mixed with cinders or gravel to make precast building blocks. Cinder blocks are rougher and grayer than cement blocks.
A house at . . . (address)	Brownstone	This is a sandstone. It used to be used a great deal because it was obtained locally in the Palisades. See how badly it scales.
A house at . . . (address)	Slate roof	Notice the different colors of slate. Slate roofs are expensive but they last long.
. . . (address)	Stones between the two houses	These are chips of bluestone placed over the earth in the driveway to prevent rain from washing away the soil.

15. How are rocks formed?

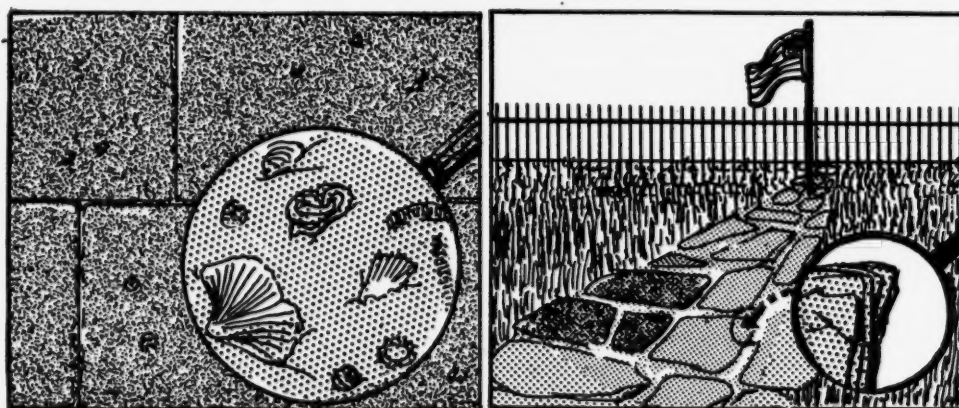
From experiences and observations in the previous activity, some children may become interested in determining the origin of rocks. As a result of their reading, research, and discussion, children will learn that rocks originate in three different ways.

a. Igneous rocks

Igneous rocks are those formed by the cooling and hardening of molten rock from within the earth's crust. The solidified lava of a volcano is igneous rock. Granite is an igneous rock.

b. Sedimentary rocks

When sand, mud, bits of other rocks, and remains of plant and animal life settle below the ocean, the bottom layers are subjected to great pressure. After millions of years the particles become cemented together into layers of rock. On close examination of some of these rocks, one can see fossilized remains of plants and animals. Limestone, sandstone, shale, and bluestone are common sedimentary rocks.



Fossils in limestone (sedimentary rock). Slate (metamorphic rock).

c. Metamorphic rocks

When sedimentary or igneous rock is subjected to tremendous pressure and heat over a long period of time, the rock changes in structure and appearance. The changed rock is called metamorphic rock, which means *changed in form*. Marble is a metamorphic rock which was changed from limestone. Slate was changed from shale.

- *There are three large groups of rock: igneous, sedimentary, and metamorphic.*
- *Igneous rocks are those made by cooling and hardening of molten rock from inside the earth.*

- *Sedimentary rocks are those formed by the binding together and hardening of bits of other rock and plant and animal skeletons.*
- *Metamorphic rocks are changed rocks.*

16. What is bedrock?

Some children may be given a research assignment to find out about the structure of the earth. They will learn that a short distance beneath the soil there is a mass of rock called bedrock. Discussion should reveal that the weight of all of the skyscrapers in Manhattan rests upon this bedrock.

In certain places in our city this rock projects through the earth and may be seen as a rock outcrop. In parts of the city where bedrock does not show on the surface, it may be observed in excavations for buildings.

Loose chunks of rock which are on the surface of the earth or on other rocks are called boulders. Most of these boulders have been carried to our city from great distances by former glaciers. Many of these can be seen in our parks.

More information and activities dealing with rocks can be found in *Operation New York*.

- *Everywhere under the streets of New York City you can find rock, if you dig deep enough.*
- *The skyscrapers of New York stand on bedrock.*
- *In some places the bedrock comes above the surface of the land.*
- *Most of the large boulders seen in parks and empty lots were dropped there by glaciers that moved over New York City many thousands of years ago.*

EVALUATIVE ACTIVITIES

1. Take a trip to an unfamiliar street. How many building materials can children recognize?
2. Ask children to report on what building materials are used in their own dwellings. How many previously-identified materials are named? Do children distinguish between natural and man-made materials?
3. Ask children to report on evidences of wear (rusting, cracking, wearing down, tarnishing, chipping) that they observe on their way to school. How many of these are observed? Are children able to name the materials which are affected?
4. Underline the rock you would choose for each of the objects listed.

GRADE THREE

- | | |
|---------------------------------------|--|
| a. <i>Curbstone</i>
Why? | granite slate marble (Granite.)
(Very hard; not slippery.) |
| b. <i>Tabletops</i>
Why? | limestone marble clay (Marble.)
(Smooth; hard; attractive.) |
| c. <i>Scouring powders</i>
Why? | shale limestone pumice (Pumice.)
(Fine powder; not scratchy.) |
| d. <i>Fronts of buildings</i>
Why? | mica limestone shale (Limestone.)
(Cuts easily, readily available, attractive.) |

BASIC SUPPLY LIST FOR ROCKS AND HOW WE USE THEM

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- | | |
|-----------------------------|---------------------------------|
| *1 bag Soil | *1 set Common Metamorphic Rocks |
| *2 Candles | *1 set Common Sedimentary Rocks |
| 2 Asbestos Squares | 2 pocket Magnifying Glasses |
| *1 set Common Igneous Rocks | 5 lbs. Sand |

G-1: General Supply List

- | | |
|------------------------|-------------------------------|
| *5 large sheets Oaktag | *1 pkg. Clay (self-hardening) |
| 1 Hammer | *5 lb. plaster of Paris |
| *1 box Chalk | *1 pkg. wooden Beads |
| 2 Chalkboard Erasers | |

Miscellaneous:

- | | | |
|----------------------------|-----------------------------|--|
| *1 box iron Nails | 10 small milk Containers | Assorted Collection of: |
| 1 glass Jar | 2 small cardboard Boxes | *Pebbles |
| 2 insulated ice cream Bags | 2 Tablespoons | *Rocks from the neighborhood |
| *1 dull Knife | 2 Cigar Boxes | *Flooring Tile |
| *1 bottle Vinegar | 2 pieces of Cloth 12" x 12" | *Ceramic Tile |
| *1 bottle Lemon Juice | *1 Brick | *Glass |
| *2 glass Tumblers | *2 large paper Bags | *Wood |
| *5 lbs. Cement | | *Man-made Rocks: tile, cinder block, brick and porcelain |



Grade Four



Finding Direction With a Compass

A. FINDING THE WAY HOME

Background for the Teacher

For many centuries, men have drawn maps to represent parts of the earth. The symbols and colors on a map convey certain facts about the area shown. With these symbols man can orient himself to his environment and locate places on the earth.

Before a map can be used correctly, it is necessary to determine which direction represents the north. This establishes the other cardinal directions as well. The designation *North* on a map refers to the direction toward the geographic North Pole of the earth.

Directions can also be determined by relating them to the sun's position in the sky at different times of the day. In the early morning the sun appears in the eastern sky and in the late afternoon it appears in the western sky.

Approaches and Learnings for the Child

Many children have seen or used a map at one time or another. They may have seen a map in a story about "buried treasure," or used a map during an automobile or airplane trip they have taken.

From the activities suggested, children learn the following.

Landmarks help us find our way.

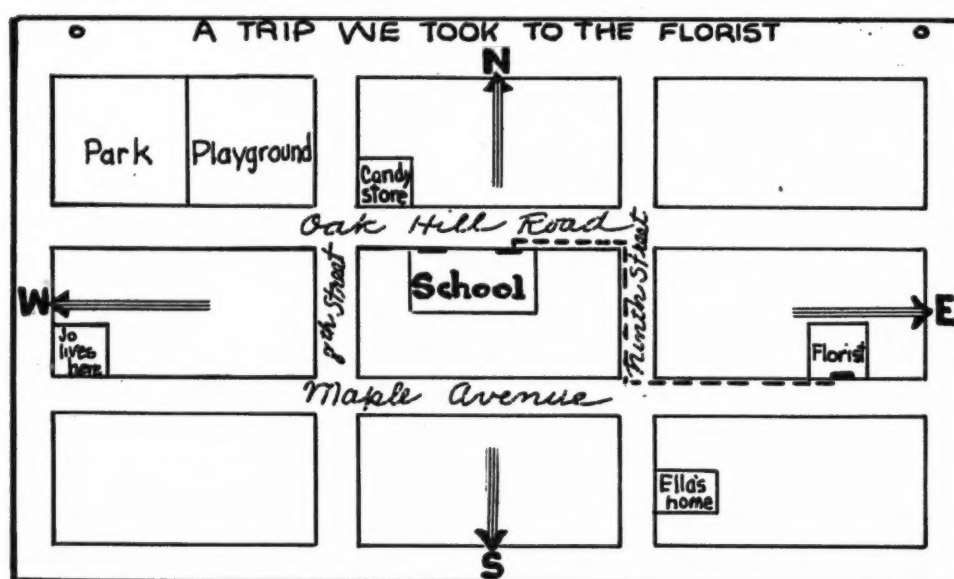
A map represents an area of the earth, and shows certain facts about the area.

We can find direction from the sun's position at different times of the day.

1. How do we find our way home?

Elicit from the children the idea that they use the classroom location, the hallway, the school street, and other physical landmarks as guides to help

them find their way home. Direct the discussion to the use of familiar landmarks, such as nearby rivers (East River), and street signs indicating direction (S. 11th Street). Make a map of the area around the school. (Plan it on the floor, then lift it to the chart rail.) Plan some trips on the map, and then take them. Note: Additional activities may be found in Curriculum Bulletin 1959-60, Series #6, *Teaching Map and Globe Skills*, pp. 13-17.



A map of the school neighborhood can be made by children.

As children develop map skills, they begin to use the cardinal directions North, South, East, and West on their maps and as directional labels on the classroom walls. They may use their skills in the construction of a "Best-Route-to-School-from-My-Home" map.

- Landmarks are places and things which help us know where we are, such as streets, street signs, trees, stores, factory chimneys, and buildings.
- Maps help us plan trips.
- To find our way, we use landmarks we know.

2. How could we find our way if we had no landmarks to guide us?

Ask children to make believe that the landmarks—streets, signs, trees, hills, buildings—between the school and their home disappeared. How could they find their way home? Encourage a free discussion and list the suggestions.

GRADE FOUR



Finding directions from the sun.

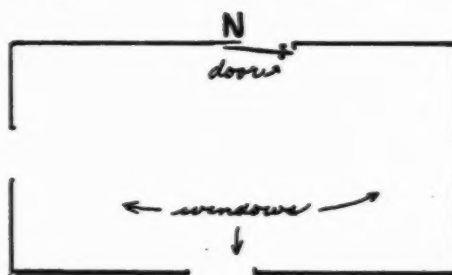
Ask children to point in the direction of their homes. Would it help if they knew that their home was west (or east, or north or south) of the school? How would it help? How would they know which way was west? (Clue: The sun rises in the east; sets in the west.) Encourage children to look for (but not at) the sun in the morning and in the late afternoon. From the sun, have them orient themselves with respect to east and west, north and south. Guide children to see that if they know one direction, they can orient themselves with respect to the others. For example, if they look in the direction of the sun in the morning, they are looking towards the east. East is in front of them, west behind, north on their left, and south on their right.

Children will need practice in locating and pointing in these directions in the classroom and in the playground, or on a sidewalk near the school. If feasible, go to a high place (hill, upper story of a building) and then survey the neighborhood to the east, west, north and south.

- *We can find direction from the sun.*
- *If we know one direction, we can find the others.*

EVALUATIVE ACTIVITIES

1. Add the directions S, E, and W to this map of the classroom.



2. In the picture of the classroom above, show which window the sun would be shining through when you come into school in the morning. (East.)

Which window would it be shining through when you leave at 3 P.M.? (West.)

3. Fill in the blanks in the sentences below. Use the map to help you.

a. Eighth Street is _____ of the school. (North.)

_____ north, south, east, west

b. Hoyt Avenue is _____ of the school. (East.)

_____ north, south, east, west

c. The theater is _____ of the school. (West.)

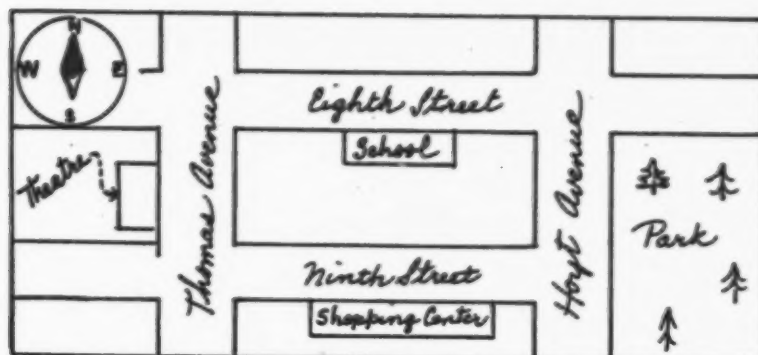
_____ north, south, east, west

d. The park is _____ of the school. (East.)

_____ north, south, east, west

e. The shopping center is _____ of the school. (South.)

_____ north, south, east, west



B. FINDING THE WAY WITH A COMPASS

Background for the Teacher

The essential part of a magnetic compass is a strip of a magnetized steel supported on a pivot so that the strip can swing freely. (In some compasses the entire dial, or face, swings about. In such compasses the magnets are usually attached beneath the cardboard dial.)

Under the influence of the earth's magnetic field (see *Background for the Teacher*, Topic D), the needle of a compass comes to rest in a north-south position. But since the magnetic poles do not coincide with the geographic poles, the compass does not, in general, point to the geographic or *true* north and south. On the Atlantic coast of the United States the needle points west of true north while on the Pacific coast the needle points east of true north.

Much of the earth's surface has been studied to determine the variations of the compass needle from geographic North and South. It has been found that these variations change from time to time; nevertheless the maps of the variations are reliable enough for navigators and surveyors.

Approaches and Learnings for the Child

Most children have handled a compass at some time. They see compasses used by the Boy Scouts. They also are used by sailors, explorers, aviators, astronomers, and motorists. Points of the compass are indicated on most maps. The children find out how to use a compass to determine direction. They become aware of North, South, East, and West in the neighborhood.

From the activities suggested, children learn the following.

A compass helps us tell directions.

One end of a compass needle points in a northerly direction.

1. How could you tell directions if you had no sun and no landmarks to guide you?

Discuss the following question. Under what conditions would you have no landmarks and no sun? Encourage children to suggest various places in which they would be unable to orient themselves with respect to the cardinal directions. How would you find directions in a cave or forest, on an ocean or a desert on a cloudy day? (You could use a compass.)

Distribute compasses and sheets of paper. Have each child place the compass on the paper so that the needle swings freely. Give the following instructions. With a pencil, make lines on the paper which are an extension of the compass needle, indicating the position of the needle. Then, draw a circle around the compass box. Rotate the compass box and then replace it in the circle on the paper. Children will note that the compass needle continues to point in the same direction. Ask all the children to point in that direction. The children observe that every needle points in the same general direction regardless of the position of the compass box.



No matter what the position of the compass case (note knob) the needle always points in a North-South direction.

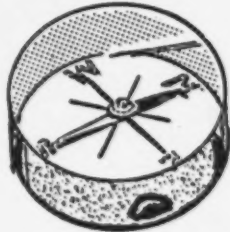
The compass needle points in a North-South direction. It is the blue (or otherwise identified) end of the needle that points in a northerly direction.

Again set the compass on a sheet of paper and write N on the appropriate pencil line on the paper. Indicate where South, East and West are.

- *One end of a compass needle points in a northerly direction.*

- *We can use the compass to find out which way is North.*
- *If we know where North is, we can find the other directions.*

2. Where is North in our neighborhood?



Give children compasses and go to a convenient area in the playground or street. Use the compass to find the North. Ask the children to point to the North. Use the compass to find the other directions. Have the children point to the South, East and West.

Plan a trip (or treasure hunt) using a compass. *For example*, start at a flagpole or tree. Walk ten giant steps towards the North. Find a tree with round seedballs. Walk five steps towards the East. Find an X chalked on the pavement. Walk 15 giant steps to the South to find a penny.

Ask children what direction they would have to walk to get back to the flagpole. (Northwest.) Children should be encouraged to design their own compass trips and to try them out with their classmates.

- *A compass helps us to plan trips.*

3. How do we use the letters on the compass to help us find our way?

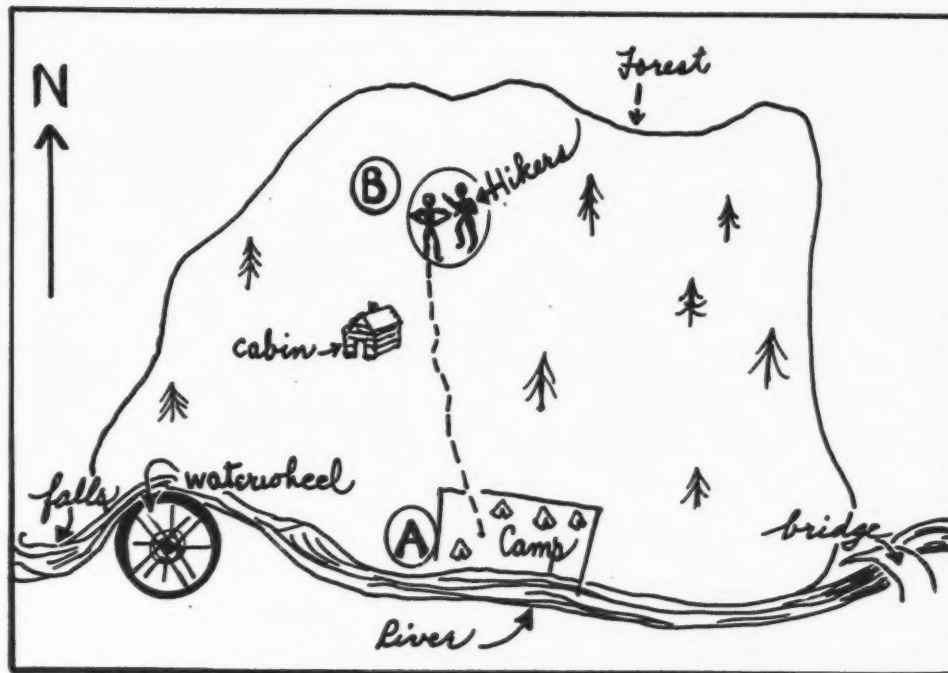
Children have seen that it is possible to turn the compass case without disturbing the direction of the compass needle. Have them turn the case until "N" is under the blue end of the needle. The other letters will confirm the directions that the children may know already. They can now get a more exact orientation.

- *When the letter "N" is turned under the blue end of the needle, the South, West and East are located quickly.*

4. How might a compass help if you were lost in the woods?

Ask children to relate experiences of being lost. How might a compass help bring them back to a designated place (camp, town, highway?)

Show children this map and use it to develop the following situation with them. Two hikers walked through a forest, from A to B, but not on any beaten path. They had a map of the area, and a compass with them, which they looked at frequently because they wished to go in a northerly direction to a cabin in the woods. After about an hour they realized that they had missed the cabin and wished to return to camp. What

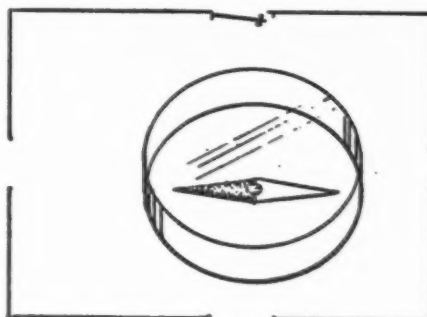


should they do? (Use the compass to go in a southerly direction.)
 What should they do if they reach the river east or west of the camp?
 (Use familiar landmarks and walk alongside the river back to the camp.)

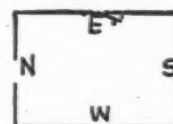
- A compass helps in planning trips, especially where there are no paths.
- A map is useful in planning a trip.
- Landmarks help us find our way.

EVALUATIVE ACTIVITIES

1. If someone gave you a compass like the one in the picture below, (without the letters N-S-E-W on the compass card) how could you use it to show directions in your classroom? (Find North with the compass needle, and then find the other directions from North.) Show where you would put N-S-E-W on the walls of the classroom in the picture.



ANSWER:



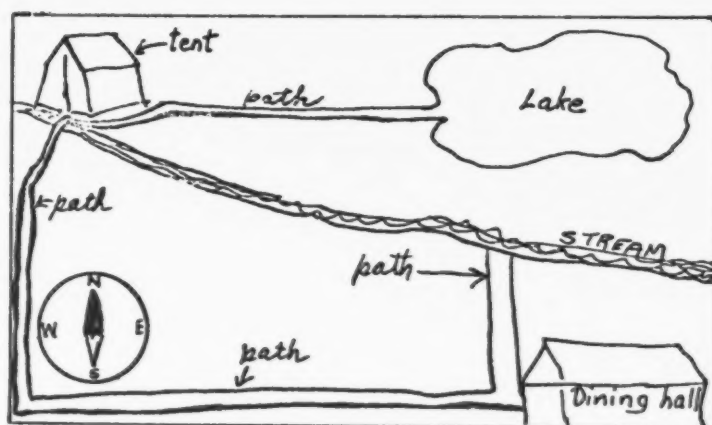
2. A boy placed a compass on a table. The needle came to rest in the position shown in the picture.
- Is the needle pointing in a north-south direction? (Yes.)
 - Do the letters on the dial show the correct north and south directions? (No.)
 - If the letters on the dial are not in a correct position, what would the boy have to do? (Turn the dial until the "N" is under the darker point of the compass needle.)



- d. Show how the compass would look when the dial is in the correct position.



3. Use the map below to help you answer the following questions.
- In which direction will a boy walk from tent to lake? (East.)
 - In which direction will he go if he follows the path from the dining hall to the stream? (North.)
 - In which direction will he go if he follows the paths from his tent to the dining hall? (South and then East.)
 - In which direction will he go if he walks along the creek to his tent? (West.)



4. Have the class play a game in which clues contain compass directions. To heighten the fun, include requests for various stunts or activities with each clue. This game can help you to determine whether children have learned where N-S-E-W are in relation to the school. Adapt the game to your school surroundings. In the sample given below, you may wish to substitute a lamp-post for a tree, a fire hydrant for a rock, etc.

Sample

Clue 1 — Leave the school through Exit 3. Walk ten paces to the pine tree. Look for Clue 2.

Clue 2 — Before leaving the pine tree, count the total number of needles in three bundles. Turn west and walk as many paces west as there were needles in the three bundles. Clue 3 is under the big rock.

Clue 3 — Did you see any insects under the rock when you picked up this paper? If so, what kind? How many legs do insects have? Turn north and walk that many steps to the fence. Look for Clue 4.

5. In the park or on a trip, play a game similar to the one previously described but which does not require advance preparation. Here the children should use a compass since they might not know where N-S-E-W are.

Sample

Step 1 — Use your compass to find north. Walk north until you reach the first tree. List three things you observed about that tree.

Step 2 — Walk ten steps west. Look for the sun. In what direction is it?

Step 3 — Find north again. Walk north until you find the first man-made item on the ground.

Step 4 — Look around for a large rock. In what direction is it from you? Walk in that direction to the rock.

C. MAKING A COMPASS

Background for the Teacher

When a bar magnet is suspended so that it can swing freely, it comes to rest in a north-south position. During the Middle Ages, crude magnetic compasses were made from pieces of iron magnetized by being rubbed with a lodestone (an iron ore which is naturally magnetic).

A compass much like those used by early mariners can be made by magnetizing a steel darning needle and then placing it on a cork floating in water. The container for the water, of course, should not be made of iron. This kind of compass is essentially the type used by Columbus in his voyage to America. Needles in Columbus' time were made of soft

iron and did not retain magnetism for any great length of time. Thus, it was necessary to magnetize a needle every few days by rubbing it on a lodestone.

The discovery of the magnetic compass marked an important milestone in man's struggle to explore his planet. No longer did mariners have to steer their boats by the North Star or by landmarks along a coast. With the compass, directions could be determined accurately even when land was out of sight or when clouds hid the sun or stars from view. This valuable instrument made it possible for men to venture out into the great unknown oceans of the world.

Approaches and Learnings for the Child

Children study compasses to see how they are constructed. They discover that an ordinary magnet can be used as a compass. They learn how to make their own compasses with commonplace materials.

From the activities suggested, children learn the following.

A free-swinging magnet comes to rest in a north-south position.

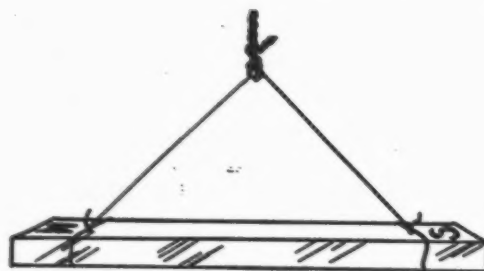
A steel needle can be magnetized by rubbing it on a magnet.

1. How is a compass built?

Obtain an old or cheap compass and take it apart. Examine the needle and the point it turns on to see if it is balanced and can swing easily. Touch the needle to lightweight iron objects, such as thumbtacks, staples, carpet tacks and paper clips. Does the needle pick up the object? Why? Does the needle pick up non-iron objects, such as plastic buttons, bits of paper, and small pieces of a rubber band? Why? Discussion should develop the idea that a compass needle is a magnet.

- *A compass needle is well balanced and can turn easily.*
- *A compass needle is really a magnet.*

2. How can we make a compass with a magnet?



A free swinging magnet comes to rest in a North-South direction.

Tie a fine string or thread to the ends of a bar magnet. Suspend, as illustrated. Allow the magnet to stop turning. What position is it in? Does it point north and south? How does it compare with the needle of a compass? What happens to the magnet if it is disturbed? Does it return to the North-South position?

GRADE FOUR

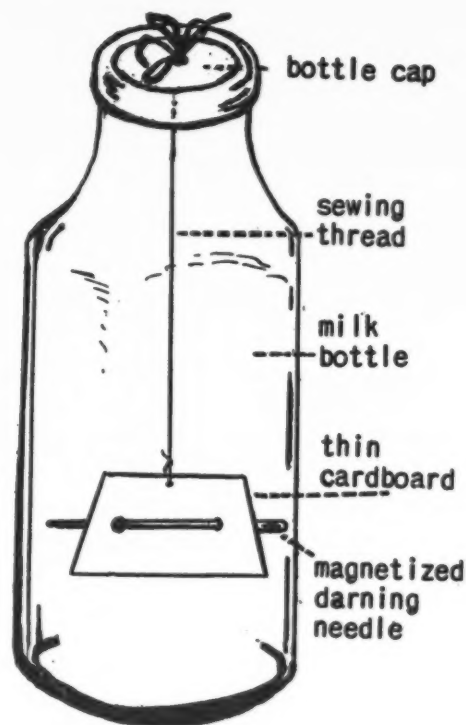
Attach labels to each end of the magnet; indicate "N" for north, "S" for south.

- *When a magnet hangs so that it can turn freely, it comes to rest in a North-South direction.*
- *A free-swinging magnet may be used as a compass.*

3. How can we make a compass with a darning needle?

Make sure the darning needle is not already magnetic by testing to see if it picks up small iron objects like pins or tacks. To make a magnet out of the needle, rub one end of it against one end of a magnet. Rub about a dozen times in one direction. Now test it again with iron objects to see if it has become magnetized.

Suspend the needle as shown in the illustration. The bottle serves both as a convenient device for suspending the needle and as a way of preventing air from blowing the needle around.



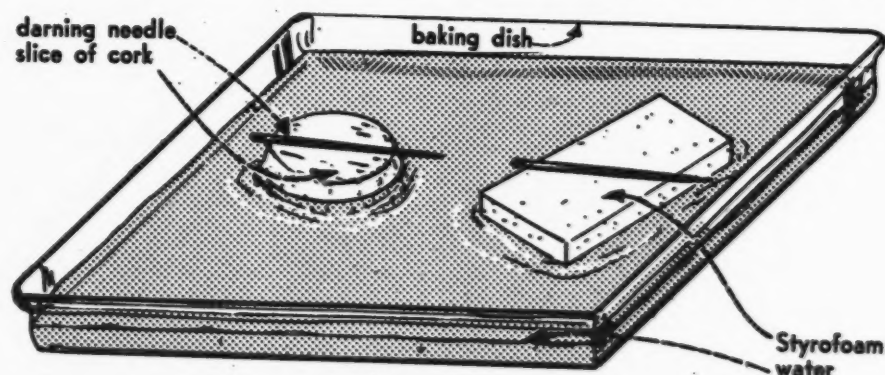
- *A steel needle can be made into a magnet by rubbing it along a magnet.*
- *A compass can be made with a magnetized darning needle.*

4. How can we make a floating compass?

Magnetize a large needle by rubbing one end with one pole of a strong

magnet, about a dozen times in one direction. Float on a slice of cork or on a piece of Styrofoam.

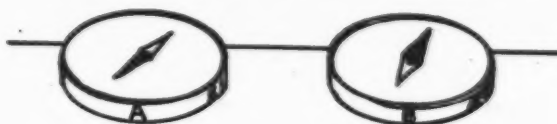
- *When a steel needle is magnetized and can turn freely, it is a compass.*



Two floating compasses.

EVALUATIVE ACTIVITIES

1. If you hold a magnetized needle in the palm of your hand, will it point north and south? (No.) What reason do you give for your answer? (It must be able to swing freely.)
2. Julio's compass looked like *A* and Hannah's looked like *B*.



- a. Where is North? (You cannot tell from these compasses since they point in opposite directions.)
- b. How could you find out if either one was correct? (Use the sun for a guide; use landmarks for guides; compare with many other compasses.)
- c. If a compass does not work correctly, what might be some of the reasons? (Needle is off the pivot; compass might be near an iron object, a magnet, or another compass; the needle has lost its magnetism.)

D. THE EARTH AS A MAGNET

Individual children, groups, or classes showing special interest in compasses may wish to continue their explorations, using the methods described in the following problems.

Background for the Teacher

We might think of the earth as a huge magnet in space, exerting magnetic

attraction around itself. What is the nature of magnetic attraction? We do not know the full answer to this question, but we can trace the shape, direction, and strength of the invisible *magnetic field* that exists around a magnet. This field can be explored with small bits of iron—iron filings. (Iron filings are not given to children because of the possibility that they may rub them into their eyes with their fingers.) A bar magnet is put on a table and covered with a sheet of paper. Iron filings are then sprinkled on the paper. A very interesting pattern develops as the iron filings come under the influence of the magnetic field. Each bit becomes a tiny temporary magnet and takes a position following the so-called lines of force that extend from the magnet. Together the filings form a map of the magnetic field. They reveal the presence of the invisible lines of force.

Similarly, in the case of the earth, invisible lines of magnetic force extend from one magnetic pole to the other magnetic pole, setting up a *magnetic field* around the entire earth. This magnetic field exerts an influence on compasses, causing them to line up in the direction of the *lines of force* in the field—which is a generally North-South direction.

The needle of a compass does not point exactly toward the *geographic* North and South Poles that mark the ends of the imaginary axis of the earth. Rather, it is attracted to the *magnetic* poles in each hemisphere. These poles are located at some distance from the geographic poles. As a result, compass needles at most places on the earth point somewhat east or west of true north. See illustration page 171.

Approaches and Learnings for the Child

Children experiment with a suspended magnet and observe that it always points in the same direction. They discover that a magnet can be deflected from this position by the proximity of iron or another magnet. They speculate about the problem, "What makes a compass needle point north and south?"

From the activities suggested, children learn the following.

A free-swinging magnet may turn away from a North-South position when it is near iron or steel objects, or another magnet.

Unlike poles of magnets attract each other; like poles of magnets repel each other.

The earth behaves like a magnet.

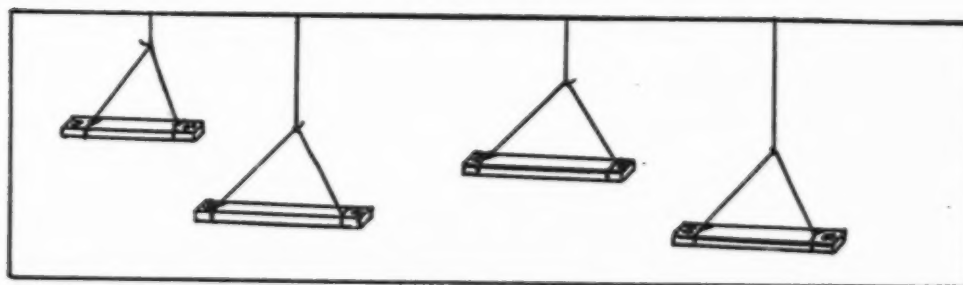
Compass needles point the way they do because of the earth's magnetism.

The earth's magnetic poles are not the same as its geographic poles.

1. Do all magnets point in the same direction?

(This activity will serve as a review of *Topic B*.)

Suspend several bar magnets around the room, each from a fine thread tied to the ends. Allow them to stop turning. Do they all assume the same position? Ask children to deflect the magnets from their positions by moving them gently clockwise or counterclockwise with their fingers. Do the magnets eventually resume the same position? Why? What makes the magnets turn? What is pushing or pulling them? Encourage the children to speculate and to propose theories, but postpone full discussion of the problem until later (see *Problem 4*).



All the bar magnets point in a North-South direction.

- *Our free-swinging magnets all point in a North-South direction.*

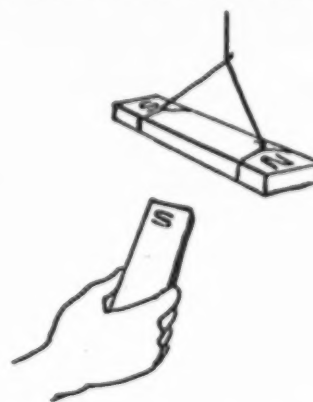
2. Does it make any difference where in the room we hold the swinging magnet?

Children walk near a radiator or metal cabinet with one of the suspended magnets. Have them observe the changes in the way the magnet "points." Also encourage children to observe and discuss what happens when a free-swinging magnet is brought near another magnet.

- *A free-swinging magnet turns away from its North-South direction when it is near iron or steel objects.*
- *A free-swinging magnet turns away from its North-South direction when it is near another magnet.*

3. What happens when the ends of two magnets are brought near each other?

Children mark magnet ends "North" or "South" depending upon the way these magnets align themselves when suspended freely from a fine thread.



Unlike poles attract each other.

Ask them to bring another magnet close to the freely swinging magnet. Children will draw conclusions from this activity.

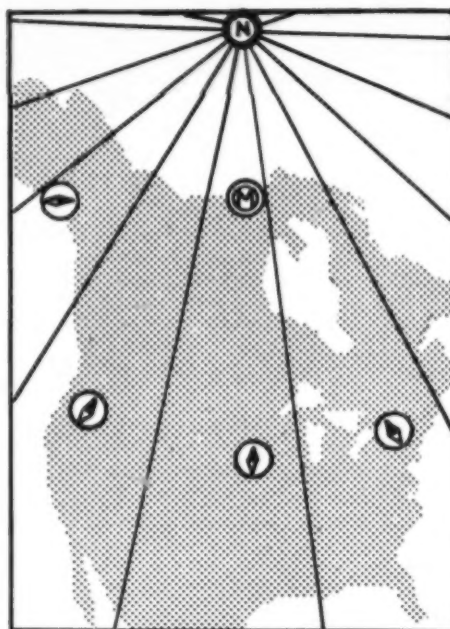
- *Unlike poles of magnets attract each other.*
- *Like poles of magnets repel each other.*

4. Why does a free-swinging magnet point to the North and South?

This question was introduced in *Problem 1*, where children were asked to offer hypotheses. Here is a good place to review what has been learned about magnets and compasses.

- a) Compass needles point in the same direction: a North-South direction.
- b) The compass needle can be deflected by another magnet or by objects containing iron.
- c) Like magnetic poles repel each other; opposite poles attract each other.

Bring a globe into the discussion. Ask the class in which direction they think the needle would point as they "travel" with a compass from San Francisco to London. (In a generally northern direction.) Some children may suggest that the whole earth is a magnet which influences the magnets in our compasses.



Compass needles point to the magnetic pole (M).

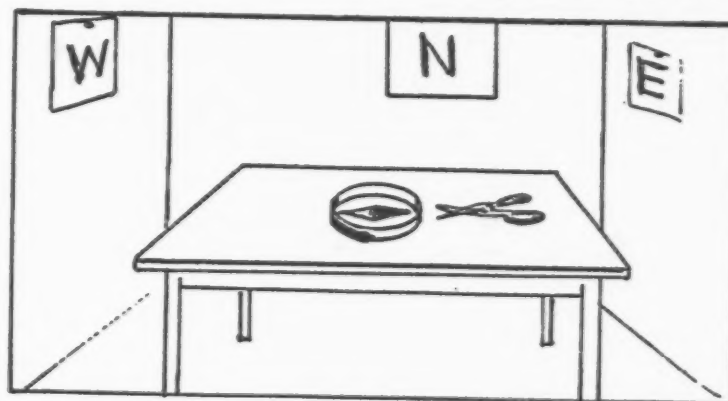
The compass needle points to what is called the magnetic pole of the North, which is twelve hundred miles away from the geographic North

Pole. Similarly, the magnetic pole of the South is some distance from the geographic South Pole.

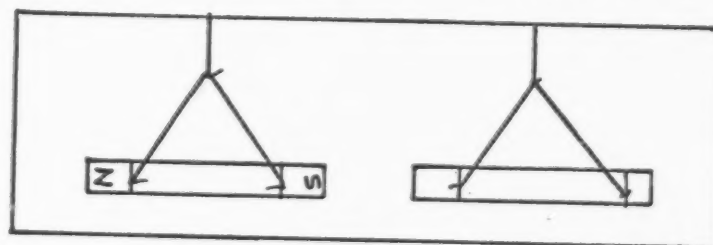
- *The earth acts as a magnet.*
- *A compass needle points the way it does because of the earth's magnetism.*
- *The magnetic pole of the north is not the same as the geographic pole of the north.*

EVALUATIVE ACTIVITIES

1. In the classroom pictured below, a compass and a pair of scissors are on a desk.
 - a. Does the compass show the correct directions? (No.)
 - b. How do you know? (The needle does not point north.)
 - c. If the compass is not pointing in the correct direction, what might be the reason for this? (The compass needle is attracted to the scissors.)
 - d. How could you find out if your answer to the above question is correct? (Remove the scissors and see what happens.)
 - e. If the compass was not correct, draw another compass on the table showing how the needle should point in this room. (Should point north.)



2. Two bar magnets are suspended next to each other. Show where "N" and "S" should be on the unlabeled magnet. (North at left, south at right.)



BASIC SUPPLY LIST
FOR FINDING DIRECTIONS WITH A COMPASS

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- 2 Compasses
- *1 old or cheap Compass
- 2 Bar Magnets
- 2 strong Horseshoe Magnets
- *2 large plastic Basins
- *1 Geographic Globe

G-1: General Supply List

- 4 sheets of 8½ x 11 Paper
- 4 Pencils
- *1 box Thumbtacks
- *1 box Paper Clips
- *1 spool of Thread
- 2 Rulers, 12"
- 4 Darning Needles
- 4 3" x 5" Index Cards
- 4 notched Corks

Miscellaneous:

- 2 Milk Bottles with caps



Our Nearest Neighbor in Space: The Moon

A. SEEING THE MOON

Background for the Teacher

Unlike the stars (including our sun), the moon does not make any light of its own. Moonlight as we see it is sunlight that has traveled first to the moon and then to the earth; in short, moonlight is reflected sunlight.

The moon's diameter is roughly about one-fourth that of the earth; its volume is about one-fiftieth that of the earth. If a tennis ball represents the size of the moon, then a basketball would represent the size of the earth.

The main types of land formations on the moon are its mountain ranges, craters, and marias (seas). Despite the derivation of the word, marias are not seas, nor is there any evidence that they ever were seas; they are large, smooth areas which appear darker than the rest of the moon. The mountain ranges average from 5,000 to 1200 feet high; some are 26,000 to 33,000 feet. (Earth's Mount Everest is 29,000 feet.) The "man-in-the-moon" is our naked-eye impression of the dark marias and the light mountain ranges. An example of a crater is Copernicus, which is one of the most beautiful. It has a ring wall which is 12,000 feet high at its highest point, a diameter of 56 miles and a floor which is depressed below the level of the surrounding territory. Most of the thousands of craters on the moon have large central peaks.

Approaches and Learnings for the Child

As interest in space grows, children look with greater fascination at the moon, one of the targets of spacemen. Teachers can use this interest, and help children to distinguish fact from fancy. Children who have access to telescope or field glasses should report on their actual observation of the moon. The best time of the month to observe the moon is during the first or last quarter as the surface characteristics show clearly at these times.

From the activities suggested, children learn the following.

Moonlight is reflected sunlight.

The moon seems to change its shape.

The moon's uneven appearance (the "man-in-the-moon") is due to the bright and dark areas of its surface.

The moon is about one-quarter the diameter of the earth.

The moon has mountains and plains.

1. Why do people say that there is a man in the moon?

Ask the children to tell what they see on the moon when it is big and round. Suggest that they observe the moon carefully the next time it is full. They may relate that some areas are brighter than others. Ask them what these light and dark areas remind them of. They will suggest a mouth, a nose, and two eyes, making a face—"the man in the moon."

Hang a large chart of the moon and ask children to describe its appearance. Point out the mountains, the craters and the dark, flat areas called *marias*, which means *seas*. Move the chart farther away (use hall or yard, if necessary) so that they can recognize that at a distance these areas become less distinct and blend together to give the appearance of a face.

- *People say they see "the man in the moon" when the moon is full.*
- *The moon's appearance is due to bright and dark places on the moon.*

2. What makes the moon shine?

Ask the children to think about this question. Discussion should bring out the idea that the moon does not produce light of its own, but shines because it is lighted by the sun. To show how this happens, place a dark colored ball in a dark corner of a closet and close the door until it is open only a crack. Ask children to tell you what they see when they look into the dark closet. They will be unable to see the ball. Now shine a flashlight on the ball. Children will see it easily. Repeat the experience. If the children understand that the flashlight represents the sun and the ball represents the moon, they will realize that the moon is visible because the sun shines on it.

- *The moon can be seen in the sky because it is lighted by the sun.*
- *Moonlight is reflected sunlight.*

3. How bright is the moonlight?

Ask children to compare the light on a road in the country, or a path in the park when the moon is full, with the light when there is no moon

or when only a small part of the moon is visible. Children may recall that sometimes one can read by moonlight. They will remember that, in moonlight, they were able to see the shapes of trees. Some children may remember that they were able to see shadows when the moon was full. Ask children to turn out all lights in a room at home into which the full moon is shining and to describe the effect.

- *A full moon lights up roads and paths.*
- *Sometimes we can read by bright moonlight.*
- *In bright moonlight objects cast shadows.*

4. Does the moon's appearance change?

Prepare a blank calendar for a whole month. Ask the children to look for the moon every night for the month and observe its shape carefully. On the calendar each day, have the children draw the shape of the moon as they observed it the night before. Certain phases of the moon may also be seen in the daytime sky. These should be added to the calendar. Leave blank spaces in those boxes representing the days when the moon was not seen. Save this calendar for *Problem 1*, page 179.

1958		APRIL					1958
Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	
		○ 1	○ 2	○ full moon 3	○ 4	○ 5	
○ 6	○ 7	○ 8	○ 9	○ last quarter 10	○ 11	○ 12	
○ 13	○ 14	○ 15	○ 16	○ 17	○ new moon 18	○ 19	
○ 20	○ 21	○ 22	○ 23	○ 24	○ first quarter 25	○ 26	
○ 27	○ 28	○ 29	○ 30				

- *The appearance of the moon changes.*
- *The changes from a full moon to the next full moon (the phases of the moon) are very gradual.*
- *Sometimes we cannot see the moon.*

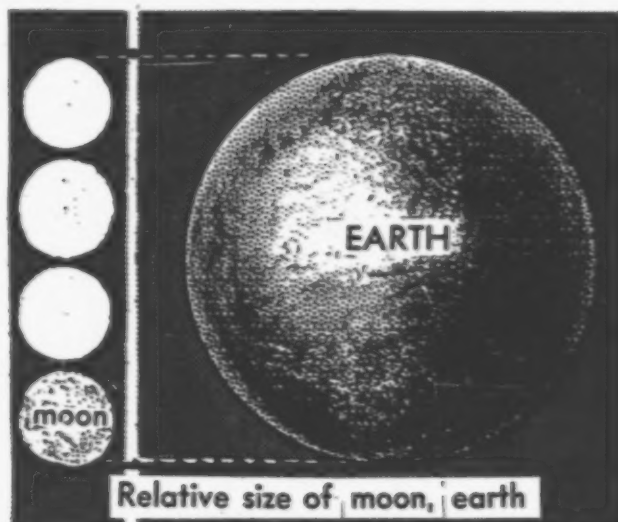
5. When can we see the moon in the sky?

Ask the children to watch for the moon in the daytime sky. Have them draw its shape and record the date each time they see it. Make these observations for a few months. Children will learn that the moon can be seen in the daytime sky from time to time.

- *The moon shines day and night.*
- *Sometimes the moon can be seen in the daytime.*

6. How big is the moon?

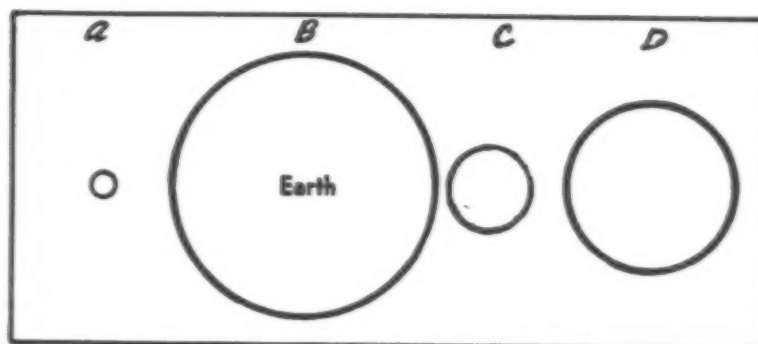
Make a collection of round objects which include basketballs, tennis balls, softballs, and marbles. Ask the children to select from it two objects which they think bear the same relationship in size as the moon and the earth. The moon is about 2,000 miles in diameter, which is about $\frac{1}{4}$ the diameter of the earth. Ask the children to suggest how to measure the diameter of the two spheres which they have selected as models. (Put each between two boxes or bookends; remove; measure the distance between the boxes or bookends.)



- *The moon's diameter is about one-fourth the diameter of the earth.*

EVALUATIVE ACTIVITIES

1. Look at the picture (top of next page). If you used a ball like the one labeled B to represent the earth, which would you use to represent the moon? (C.)



2. What is wrong with this picture? (The moon is round and solid; you cannot see through it. Also, the moon is closer to us than any star. Therefore, no star could be seen between us and the moon.)



B. MOTION OF THE MOON

Background for the Teacher

The moon is the earth's only natural satellite. It revolves (orbits) around the earth once in $29\frac{1}{2}$ days. When we see the whole lighted half, we call it a full moon. When only half of the lighted part is visible, we see a quarter moon. When all the lighted part faces away from the earth, there is "no" moon, or a new moon. If the moon is observed for a month, it may be seen *waning* from a full moon to a quarter moon to a thin crescent, and then to a new moon ("no" moon). From new moon it may be seen *waxing* to crescent, quarter, and full moon. These stages are known as the phases of the moon.

While the moon is revolving around the earth, it is also rotating on its axis. It rotates once while revolving around the earth once. As a consequence it always presents one side to the earth. (See illustration on page 182.)

During one night, the moon appears to move westward across the sky, as the sun does, because of the eastward rotation of the earth. A full moon, for example, will rise in the east at sunset and appear to travel westward all night to set in the west during the early morning.

Approaches and Learnings for the Child

As children learn more about the moon, they are encouraged to look at the sky during the day and at night, and to keep a record of what they see for a period of a month.

From the activities suggested, children learn the following.

The moon moves (revolves) around the earth about once a month.

The moon makes one turn on its axis (rotates) once a month.

The moon always presents the same side to the earth.

The moon seems to change shape in a regular way.

The moon takes about one month to go through its changes, or phases.

The moon seems to travel across the sky each night from east to west.

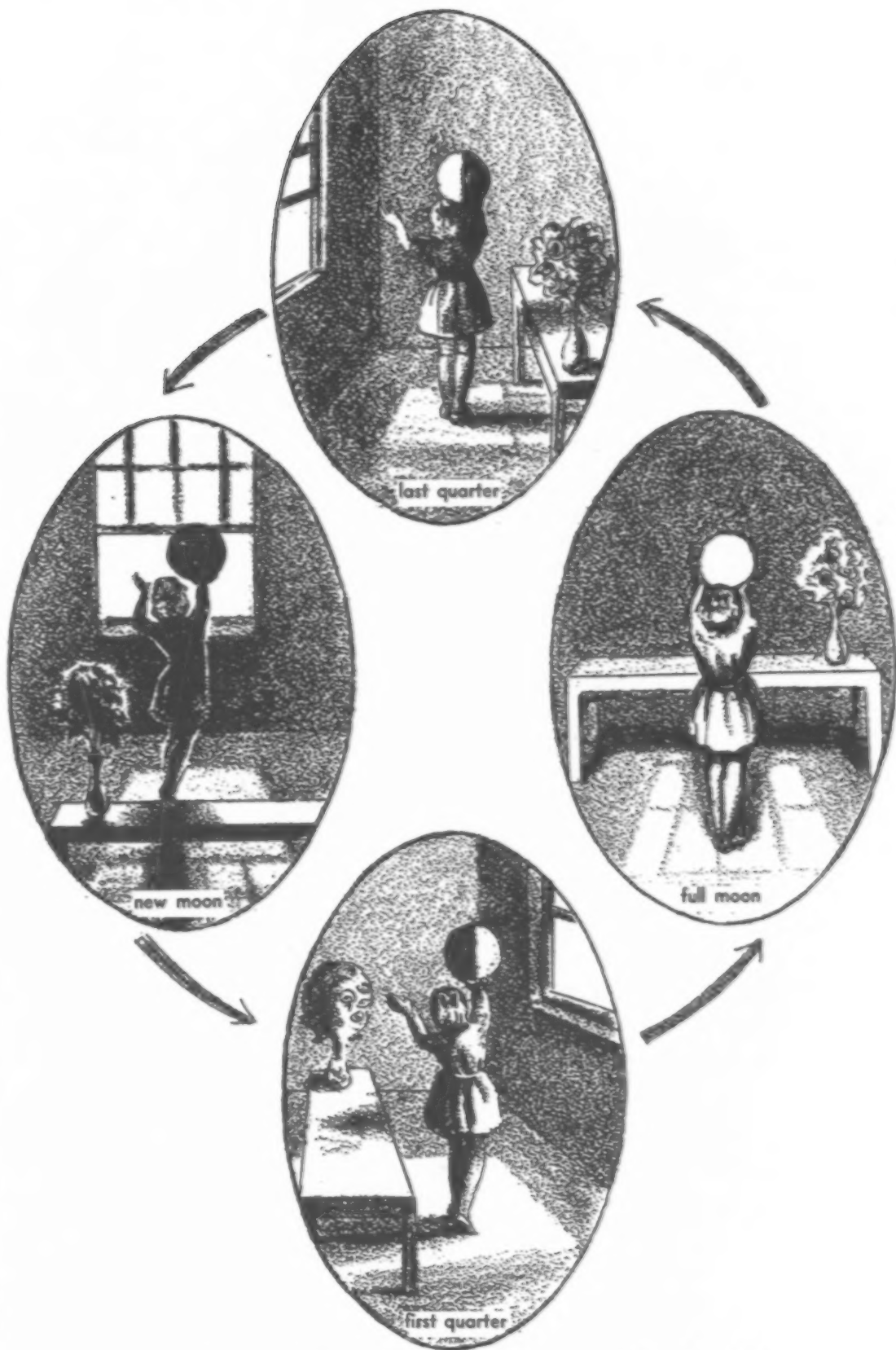
1. How many days does it take for the moon to change from full moon to full moon?

Using the moon calendar made by the children (see page 176), have them count the number of days it took the moon to go from full moon to full moon. Have the children prepare their own calendars for another month. Ask them to indicate the shape of the moon each night and to count the number of days it took the moon to pass from full moon to full moon. A committee of children should repeat this experience for a few months and report the results to the class.

- *It takes about one month for the moon to change from full moon to full moon.*

2. Why does the moon seem to have different shapes?

The different appearances of the moon can be demonstrated by using a white ball as shown on page 180. Darken the room as far as possible, with the exception of one window. A child holds the ball in front of and a little above him. Make it clear to the group that *the child's head represents the earth*. Using the light that comes through the window to represent sunlight shining on the ball (moon), ask the child to turn slowly. Since the child's head represents the earth, the observer *should not* be a second child off the earth, but the first child himself. After he makes a quarter-turn to the left, have him tell what part of the ball is lighted by the sun. Let him make another quarter-turn to the left. What does he now see of the ball? Continue this movement until the child has made four quarter-turns to the left, returning to his original position. He tells what he sees of the ball at each turn. Each child should have an opportunity of doing this. Compare the motion of the ball around the child's head to that of the moon revolving around the earth. Half of the moon is always illuminated, *but we do not always see all of that half*.



Phases of the moon as seen by the child.

- *The moon revolves around the earth.*
- *The moon seems to change its shape during the month because we see more or less of the half that is lighted by the sun.*
- *We see only one side of the moon.*

3. Which way does the moon seem to move in one night?

Suggest that the children look at the moon once an hour three times during the same night, say 6:00, 7:00, and 8:00 p.m. Have them choose a place where they can see the moon over the corner of a building or over a telegraph pole or other high, fixed object. They should stand at the same place each hour and record the new position of the moon each time. In which direction did the moon seem to have moved?

- *Because the earth turns from west to east, the moon seems to move from east to west.*

The moon seems to move from east to west.

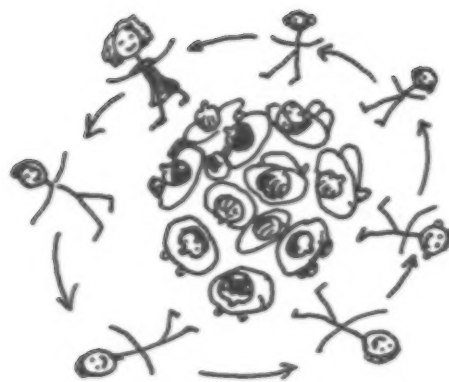


4. Why do we always see the same "man in the moon"?

Review the understandings that the "man in the moon" is our naked-eye view of the light-and-dark surfaced areas of the moon. (See page 175.) This view, however, represents only one side of the moon's sphere. Why do we see only this side of the moon from the earth? Encourage children to conjecture about this question. List their ideas on the chalkboard.

Have the children participate in the following demonstration. Let the entire class sit in a cluster in the center of the room. Select *one* child to move in a circle around those sitting in the cluster. The child circles the group in a counterclockwise direction with small side steps, always facing the group. The children in the center are "on the earth," and the child circling them is the "moon"; his face represents that side of the moon that we always see.

After the demonstration, ask the children to evaluate the ideas originally



The moon dances around the earth.

listed on the blackboard. Discussion should develop the understandings which are given below.

- *The moon moves around the earth.*
- *The moon moves (revolves) around the earth about once a month.*
- *The moon moves in a counterclockwise direction around the earth.*
- *While the moon is revolving, it rotates slowly on its axis.*
- *The moon makes one complete rotation in a month. As a consequence it always keeps the same side toward the earth.*

EVALUATIVE ACTIVITIES

1. Give each child a ball as you did when you taught the phases of the moon. Darken the room. Set up a filmstrip projector as a source of light or use the light from one window. Can the children hold their ball in the right place to make a full moon? a new moon? the first quarter? the last quarter? Ask the children (earth) to move the ball (moon) to show the motion of the moon. (Observe if children are moving their ball in a counterclockwise direction around themselves.)
2. Does the sun ever shine on the part of the moon that we never see? (Yes.) Explain your answer. (At the time of the "new moon" the part of the moon facing the earth is turned away from the sun. It is night on that part of the moon. The part of the moon we never see is then facing the sun; there it is day.) Have the children use the materials in Question 1 to illustrate their answer.
3. A girl is keeping a moon calendar. She looks out the window to see the moon one night, but cannot see it. What are some of the possible reasons for this? (It is a cloudy night; the moon may not have risen yet; it may have set; there is a new moon; her view of the moon may be blocked by a building at the time she looks; there may be a lunar eclipse.)

4. Show the children a large ball representing the moon, with a face painted on one side. Explain that the center of the room represents the earth. Ask them how they would circle around the room with it to show how the moon moves around the earth. (The child carrying the ball should move counterclockwise and hold the ball so that its "face" is always directed toward the center of the room.

C. DISTANCE OF THE MOON FROM THE EARTH

Background for the Teacher

The moon is the earth's nearest neighbor in space. Its relative proximity to the earth, about 240,000 miles, has made it an important first target in space explorations. The moon's distance from the earth is equivalent to about ten times the circumference of the earth.

The path of the moon around the earth is not an exact circle. When the moon is at its nearest to the earth (its perigee) it is 221,463 miles away; at its most distant position (is apogee) it is 252,710 miles from the earth.

Approaches and Learnings for the Child

As children plan their own imaginary trips to the moon, they will want to find answers to many questions. How far away is it? Why does it look so small? How long will it take to get there? Questions like these are answered by using models, by observation of the night sky and by reading newspapers, books, and magazines. The child is helped in relating the moon to the earth and to the sun with respect to size, distance, and position in space. He comprehends the meaning of *distance to the moon* better when he realizes that when an astronaut circles the earth ten times he is traveling a distance equivalent to the distance of the moon from the earth.

From the activities suggested, children learn the following.

The moon is about thirty "earths" away from the earth.

The moon is the astronomical body nearest to the earth.

The moon looks small because it is far from the earth.

1. How far is the moon from the earth?

The moon is about 240,00 miles from the earth. Since the diameter of the earth is 8,000 miles, the moon is about 30 earths away from us.

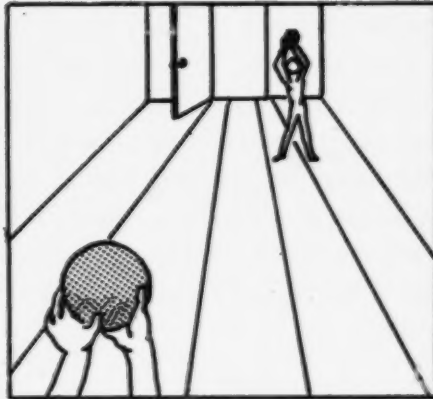
Get two balls, one about eight inches in diameter and the other two inches in diameter. The eight-inch ball represents the earth; the two-inch ball represents the moon. Imagine 30 earths lined up, one next to the other. Eight inches of diameter, multiplied by 30, gives 240 inches or 20 feet. Place the two balls 20 feet apart. This gives a vivid, realistic—and surprising—model of the distance of the moon from the earth.

- *The distance of the moon from the earth is about 30 times the diameter of the earth.*
- *The distance between the earth and moon is much greater than the size of either one.*

2. If the moon is one-fourth the size of the earth, why does it look so small?

Take the class outdoors. Have two children each hold a basketball as they face the class. Children will see that both balls are the same size. One child stands still. The other child, holding the ball, moves slowly backward away from the class for a considerable distance. Ask children which ball seems smaller. Have child return to original position facing the class. Ask children to close one eye and holding hands in front of their faces, palms facing, to indicate the size of the ball. Then as the child moves slowly backward, holding the ball, have children adjust their hands to the apparent change of size of the ball.

Try this with one child holding an eight-inch ball representing the earth, and another holding a two-inch ball representing the moon. Ask the child holding the "moon" to move about 20 feet back. How does the size appear to change as the ball moves further away? Do this in a school corridor if it is not feasible to go outdoors.



Objects that are farther away look smaller.

- *The moon looks small because it is far from the earth.*

3. How long might it take to travel to the moon?

The purpose of this discussion is to help children understand the meaning of distance like 240,000 miles, by "converting" the distance into time.

Ask children to think of how long fast-moving jets and rockets would take for such a trip. They have seen jet planes streaking across the sky,

and know that they travel at speeds approaching 1,000 miles an hour. Travelling at this speed, it would take 240 hours, or ten days, to cover the 240,000 miles between the earth and the moon.

A rocket ship, moving at a constant rate of 24,000 miles per hour, should reach the moon in ten hours *Note:* In current moon thrusts rocket ships do not travel this quickly because all of the energy is imparted to them from the initial blast-off, plus the blast from each of the stages. When the last stage is dropped, the ship "coasts" toward the moon. It then slows down considerably from 24,000 to about 6,000 miles per hour because of the influence of the earth's gravity which extends out into space. When the spaceship passes a certain point, about 9/10 of the way to the moon, the moon's gravity speeds up the rocket, but not sufficiently to make up for the previous loss. Thus it would take a spaceship about three days to reach the moon.

- *Moving at a constant speed of 1,000 miles per hour, it would take 240 hours (10 days) to get to the moon.*
- *A rocket ship on its way to the moon is slowed by the pull of the earth's gravity.*

EVALUATIVE ACTIVITIES

1. A man stood at a window half way up the Empire State Building and looked at cars on the street. Then he looked from the observation deck at the top of the building. Did the cars look the same? Smaller? Bigger? (Smaller.)
2. Give a small piece of modeling clay to each of the children. Ask them to make models to represent the earth and the moon. (Do the children make the earth model about four times the diameter of the moon model?)

Ask children to position their models on their desks to represent the distance between the earth and the moon. (Is the distance about 30 times the diameter of the earth model?)

D. MAN ON THE MOON

Background for the Teacher

The relative nearness of the moon to the earth makes it the first major target in manned space exploration. The landing of a manned spacecraft on the moon is to be expected in the very near future; a number of instrument-equipped spacecraft already have reached the moon and relayed pertinent data and photographs of the moon's surface back to earth.

There appears to be no indication of water or living things on the moon's surface, or of any significant atmosphere. The surface temperature of the

moon varies from a high of about 212°F. during the moon's day to a low of about -302°F. during its night. Under such conditions, a moon explorer will need special clothing and equipment. He will have to take his own "environment" (oxygen, water, proper temperature, and food) with him when he goes on his moon journey. The extremes of moon temperature will necessitate his wearing clothing that will insulate him from the excesses of heat and cold. He also must anticipate a world of silence, since there will be no atmosphere through which sound can travel. On the other hand, he will find that he can do some things, such as jumping or throwing an object a considerable distance, much more easily than on earth, because the moon's gravity pulls only one-sixth as hard as the earth's.

Approaches and Learnings for the Child

Man's recent accomplishments in space and the prospects of a landing on the moon have great fascination for children. Children are eager to learn the facts and explore the fancies of this next great adventure.

From the activities suggested, children learn the following.

Moon probes help us discover many facts about the moon.

Man must take his own environment with him when he goes to the moon.

There is probably no air, water, or food on the moon.

The temperature of the moon varies from extreme cold to extreme heat.

The pull of gravity on the moon is much less than that on earth.

1. How did people find out the many things they know about the moon?

Ask children to tell how they think people first learned about the moon. (They watched it night after night.) What kinds of instruments helped them later? (Binoculars and telescopes.) How were other discoveries made? Children may talk of the rockets that were sent to the moon. Have them report on different moon probes and the purpose of each. They may tell about the Russian space rocket that first went around the moon, taking pictures of the side we do not see from earth. Another rocket, American this time, went closer to take detailed photographs of the moon's surface. These pictures were sent by television back to earth. Other spaceships land there to measure heat and radiation, to "examine" material on the surface, and to send all information back to earth.

- *We can study the moon by watching it for many nights and by looking through binoculars and telescopes.*
- *We can learn more about the moon with rockets and spaceships and by landing on it.*

2. What is it like in the space between earth and moon?

Ask children to tell of an imaginary trip from the earth to the moon. The following questions may be helpful in "briefing" the hopeful astronauts.

Is there air in space? (No.)

What about earth's gravity? (It becomes weaker and weaker as you travel away from the earth.)

Can an astronaut safely leave his spaceship? (Yes, provided he has a spacesuit and a spacegun or a rope to get back.)

How fast will an astronaut travel outside a spaceship? (The same speed as his spaceship.)

Why doesn't he fall back to earth? (He is traveling fast enough to overcome earth's pull.)

What about heat in space? (The surface of objects in direct sunlight is very hot; the surface of objects in shade is very cold.)

Are there any clouds in space? (No.)

What color is the sky? (Black.)

Can you see the stars all the time? (Yes.)

How does the earth look as you move away from it? (Smaller and smaller.)

How does the earth look when you are near the moon? (Like a big moon.)

How big does the earth look? (About four times as big across as the moon looks from the earth.)

- *There is no air in space.*
- *Earth's gravity becomes weaker as you go farther away from it.*
- *The sky appears black in space, and the stars are always out.*
- *In space, the surface of objects in sunlight is very hot; the surface of objects in shade is very cold.*
- *Astronauts can leave their spaceships safely if they wear spacesuits and if they have a way of getting back.*

3. How will men live on the moon?

Ask children to "design" a moon station where men can live for a period of time. What moon conditions must be understood in the planning of such a station, and in travel on the moon outside the station? Encourage children to suggest the moon conditions men will face and to propose ways of meeting these conditions. The following are typical items, but it is essential that children propose these and others as they see the problems. A chart, such as the one partly completed here, may be used to summarize their research.

MOON CONDITION	WHAT TO DO ABOUT IT
No air for breathing	Carry a supply from earth <i>or</i> carry chemicals with which to make oxygen <i>or</i> grow sufficient green plants in enclosed moon-domes to make oxygen and remove carbon dioxide.
No air for talking	
No air for airplanes	
Extreme cold in moon's night-time and extreme heat in moon's daytime	

Other conditions which may be added to such a chart might include the following:

Sunlight may have dangerous radiation in it; no food; very lonely; man's gravity only 1/6 that on earth; sky always black; moon day about two weeks; moon night about two weeks.

- *There is no food, water, or air on the moon.*
- *Moon's gravity pull is much less than that of the earth.*
- *The temperature of the moon varies from very cold to very hot.*
- *Two weeks of daytime and two of nighttime make up the moon's full "day."*

EVALUATIVE ACTIVITIES

1. Read, or duplicate and have the children read, the following story about spacemen on the moon. Which activities in this story would *not* really happen on the moon? (Disconnect parachute; wait twelve hours until the next morn-

ing; take off the space helmet; call out; start a fire; gather wood; felt very heavy; started to rain.) Why would each of these activities not happen? Ask the children to rewrite the story correctly, or retell the story cooperatively.

It is 1970 and America has landed two men, Lunarnaut I and II, on the moon. All of America is happy and awaits word of the experiences of these two brave men.

When their space capsule came to rest on the lunar surface, the lunarnauts climbed out and stepped onto the moon. The first thing they did was to disconnect the parachute that was used to help them land safely. Then they took some samples of the lunardust. One of them spent many hours taking photographs of the craters nearby. He had to hurry because nightfall was fast approaching and he did not want to have to wait twelve hours until the next morning when it would be light enough to take more pictures.

Lunarnaut I felt cold. He took off his space helmet and called out to Lunarnaut II to start a fire so that they could have a cup of coffee. While the second lunarnaut started the fire, the first one went to gather wood to keep the fire going. After a warm cup of coffee they both felt better, though they were a little tired from walking around. They found that everything felt very heavy to them on the moon.

It started to rain, so they got back into their capsules to work on their reports and to send messages to earth by radio. They looked down on earth, and waved to the people there, although they knew no one could see them. But they wondered to themselves if any boys and girls were looking at the moon then and saying "Mother, I see the face of a man on the moon."

E. ECLIPSES OF THE MOON AND THE SUN

Background for the Teacher

A lunar eclipse occurs when the moon and the sun are on opposite sides of the earth and all are in the same straight line. These conditions exist only at the time of a full moon. Under these circumstances the earth blocks the light of the sun and throws a shadow on the moon.

A solar eclipse is one in which the sun is hidden by the moon, when it gets between the earth and the sun, and in a straight line with both. This can happen only at the time of a new moon. The moon then throws a shadow on the earth. It is only during a total solar eclipse that we can see the sun's corona (white streamers around the outside of the sun), since at other times the brighter surface of the sun obscures it. In looking at a solar eclipse it is very important to protect the eyes by covering them with a few pieces of overexposed dark camera film. *Note:* Extreme

care must be taken when looking at the sun. The sun should never be viewed through a telescope or any other optical device. To protect the eyes the sun should be viewed briefly—a second for a look—through two layers of black photographic film negatives. To prepare the negatives, remove unexposed verichrome film, expose in daylight and develop fully. The film should now have what the photographer calls a film factor of 6.0.

Approaches and Learnings for the Child

Solar and lunar eclipses are phenomena which arouse much interest especially if one should occur during the school year. At such a time it is advisable to discuss the eclipse with all the children in the school. The use of models also will reinforce children's observations and understandings.

From the activities suggested, children learn the following.

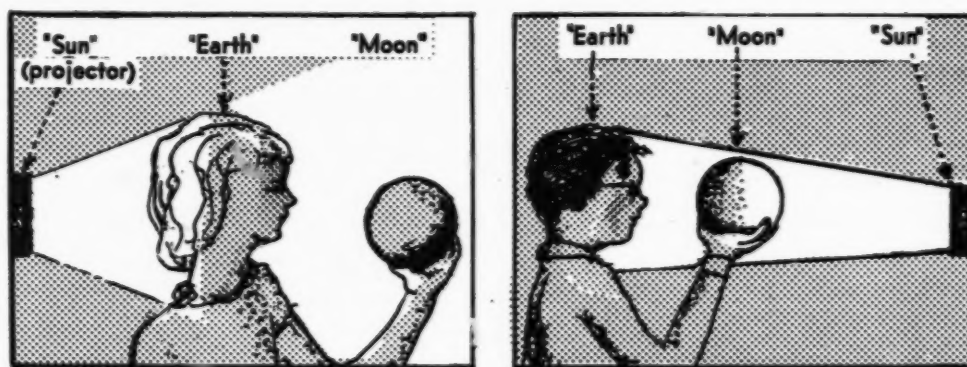
An eclipse of the moon occurs when the earth blocks off the light of the sun.

An eclipse of the sun occurs when the moon blocks off the light from the sun.

1. What causes eclipses of the moon?

This should be considered, if possible, at a time of the year when an eclipse of the moon will soon occur. Children should be prepared for such an occasion with the demonstration which follows. (Use material from the E-1 List.)

Take a ball about 4 inches in diameter to represent the moon. The child's head represents the earth. Use a filmstrip machine (or flashlight) to represent the sun which shines on the moon. The child faces away from the light and slowly moves the ball until it is in his shadow.



Demonstrating an eclipse of the moon . . . an eclipse of the sun.

Ask children to tell what the ball looked like when the "sun" shone on it. What happens when the "earth" is between the "sun" and the "moon"?

- *An eclipse of the moon happens when the earth is between the moon and the sun.*
- *An eclipse of the moon happens because the earth blocks off the light from the sun.*
- *When we watch an eclipse of the moon we see the earth's shadow pass across the moon's face.*
- *Eclipses of the moon happen only when there is a full moon.*

2. What causes eclipses of the sun?

Use the same material as in *Problem 1*. What happens when the moon comes between the sun and the earth? Compare an eclipse of the sun with an eclipse of the moon.

The following may be helpful in summarizing this discussion.

	ECLIPSE OF THE MOON	ECLIPSE OF THE SUN
SHADOW	Earth's shadow falls on the moon.	Moon's shadow falls on the earth.
POSITION OF EARTH, SUN, AND MOON	Moon-Earth-Sun	Earth-Moon-Sun
WHAT HAPPENS	Dark area moves across the moon until moon is covered by it; then it moves across and away from the moon.	Dark area moves across the sun, then away from it.
PHASE OF THE MOON	Moon is full	Moon is new (no moon)

- *An eclipse of the sun happens when the moon is directly between the sun and the earth.*
- *In an eclipse of the sun, the moon's shadow falls on part of the earth.*

EVALUATIVE ACTIVITIES

1. Ask each child to make his hand into a fist. Darken the room but have one source of light such as a flashlight, filmstrip projector, or table lamp. Tell the children that the light represents the sun, their head the earth, and their fist the moon.
 - a. Ask the children to close one eye and then position their fist so that they cannot see the light. What kind of eclipse is represented now? (An eclipse of the sun.) What is hidden from the earth? (The sun.) What is making a shadow fall on the earth? (The moon.)
 - b. Ask the children to place their fist so that it is in their own shadow. What kind of an eclipse is represented now? (An eclipse of the moon.) What is hidden from the earth? (The moon.) What is making a shadow fall on the moon? (The earth.)
2. a. What kind of eclipse may we have if the earth, sun, and moon are in the following position? (Eclipse of the moon.)



- b. Complete the following statement. In this eclipse the 's shadow falls on the (earth; moon.)
3. a. What kind of eclipse may we have if the earth, sun, and moon are in the position pictured below? (Eclipse of the sun.)



- b. Complete the following statement.
In this eclipse the 's shadow falls on the (moon; earth.)

F. FINDING OUT MORE ABOUT THE MOON

1. Do clouds pass in front of or in back of the moon?
2. Why can't you see a star inside a crescent moon?
3. Why is it hard to see stars when you look in the part of the sky near a full moon?

4. What does the sky look like on the moon?
5. When does the moon have color? What colors have you seen?
6. How can you tell if the moon is waxing or waning?
7. Explain how you can tell where the sun is by looking at the moon.
8. Why isn't the moon in the same place in the sky at the same time each night?
9. What have moon probes discovered about the dark side of the moon?
10. What do we think craters on the moon are like?
11. How much would you weigh on the moon?
12. How long is daytime on the moon?
13. What keeps the moon in its orbit around the earth?

BASIC SUPPLY LIST
FOR OUR NEAREST NEIGHBOR IN SPACE: THE MOON

*Indicates quantity for entire class; other quantities
specified are for each group of 4 children.

E-1: Science Supply List

- *1 slated Globe

G-1: General Supply List

- *1 Flashlight
- *1 dark Ball
- *Collection of assorted Balls
(Basketballs, Soft Balls, Tennis Balls)
- *1 large white Ball
- *1 box Chalk
- *2 large sheets of Oaktag

Miscellaneous

- *5 Marbles
- *1 Projection Machine
- *1 ball of String
(warp, thread-white)



Getting New Plants

A. NEW PLANTS FROM SEEDS, LEAVES, STEMS, AND ROOTS

Background for the Teacher

In the common trees, shrubs, herbs, and grasses, new plants arise from the seeds produced by the parent plants. Seeds come in a variety of sizes and shapes. They may be scattered by wind and water, or distributed by animals. The scattering of the seeds of a plant helps in locating many of them in places where they will not have to compete with the parent plant or with each other for water, for minerals, and for sunlight.

Inside the seed is the embryo plant which originated from the union of the sperm and the egg of the parent plant or plants. Thus in plants, as in animals, life begins with the union of sex cells.

But many plants have evolved asexual methods of reproduction in which a part such as the root, stem, or leaves, ordinarily used for the nutrition of the plant, may start a new plant. Such asexual methods are generally known as vegetative propagation. *Runners, tubers, bulbs, or cuttings* are the names given to the parts of plants when they are used for vegetative propagation.

The production of new plants by *runners* can be easily observed in strawberry plants. Runners are special stems which grow out from the parent plant, bend down, and produce new plants at the places where the runners come in contact with the soil. Reproduction by runners is found also in such plants as blackberry, raspberry, and forsythia.

The potato we eat is a part of the potato plant; it is a fleshy underground stem of the sort known as a *tuber*. The "eyes" of a tuber are actually the sites of stem buds. When a piece of potato with an eye is planted, the buds sprout new plants which draw upon the stored-up food of the tuber.

A well known example of a *bulb* is the onion. Bulbs are really underground fleshy leaves and the bud of a stem. A bulb has within it the nourishment necessary to start the roots, stem, leaves, and flowers of the plant which grows from it.

Another way of starting new plants is with *cuttings*. Pieces cut or broken from certain kinds of plants will develop into whole new plants under proper conditions. These cuttings are often called "slips" and are widely used to start new house plants. They may be rooted in sand, vermiculite, or sometimes merely water. Geraniums, coleus, African violets, begonias, and ivies are among the plants that may be propagated by cuttings. Certain willow trees start naturally from branches which break off from a parent tree and subsequently take root in moist soil.

Sometimes a leaf cutting may start new plants. A leaf taken (or fallen) from a parent bryophyllum plant and placed on moist soil will grow new shoots in the notches located at the margin of the leaf.

Approaches and Learnings for the Child

From their experiences and experiments, children find that new plants may be started in two different ways. In one, seeds produce plants; in the other a part of the plant (such as a stem or leaf) may start a new plant.

Children are interested in studying the ways in which seeds are scattered and in observing that they may have wings, parachutes, or hooks for this purpose. They find that seeds are produced in the flowers of plants; that the essential role of the flower is to make seeds to start new plants.

By experimentation, children discover that they can also propagate some plants, such as the geranium, willow, begonia, coleus, tradescantia, philodendron, and pothos, by planting pieces of their stems in suitable surroundings. (See *A Green Thumb in the Classroom*, p. 303.)

Since many plants will thrive better outdoors with suitable sunshine, air, and space, it may be possible for children to start plants indoors and then transplant them into the school garden. (See *The School Garden in the Science Program*, page 18.)

From the activities suggested, children learn the following.

New plants come from seeds.

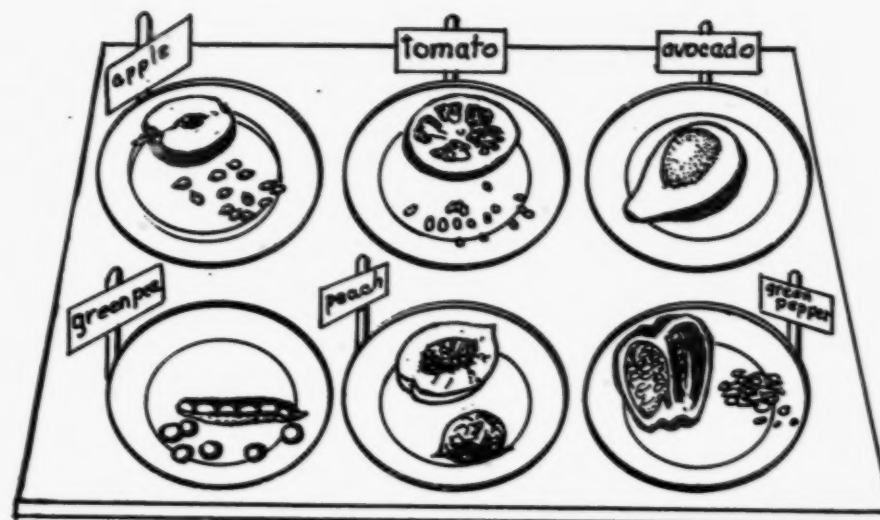
Seeds are scattered in different ways.

The scattering of seeds helps to carry many of them to suitable surroundings.

In some plants a new plant may be started from roots, stems, or leaves.

1. Where do seeds come from?

In the late spring, take children to see fruit trees in bloom. Observe the blossoms. If no fruit trees are growing in your neighborhood, plan a trip



Common fruits and their seeds.

to a botanical garden or plant nursery. Return later to see that the petals fell off, and that part of the original flower has begun to form a fruit.

Ask children to bring in a variety of fruits such as apple, pear, grapefruit, orange, avocado, peach, plum, grapes, watermelon, and cherries. Cut fruits open and have the children find the seeds inside.

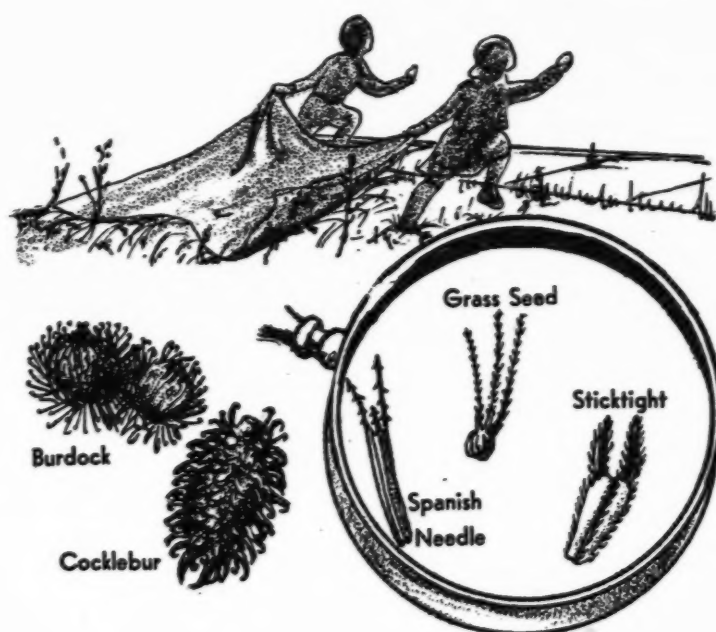
Can new plants be started from these seeds? Ask some children to plant and take care of the seeds from these common fruits. Patience is needed, for some of the seeds may take weeks or months to sprout.

- *Part of a flower becomes the fruit.*
- *In most plants seeds are found inside the fruit.*
- *New plants come from the seeds.*
- *Each kind of plant produces its own kind of seed.*

2. How do people help in the planting of seeds?

Look around the school building, in the school garden, and in nearby window boxes and gardens for plants which have grown from seeds planted there by people. What kinds of plants do you find? (Grass, some garden flowers and vegetables, some flowers in pots and window boxes.) Look at a seed catalog. Find pictures and names of plants you know or have heard about. Which seeds come from faraway places? Look at seed packets and read the information on them. Discuss why we plant seeds.

- *People plant seeds for flowers, fruits, and vegetables.*
- *People sometimes plant seeds that have come from faraway places.*



Collecting and examining hooked seeds.

3. What seeds travel by "hitch-hiking"?

In the fall of the year, take the children for a walk through a field or a vacant lot. Ask them to look, while walking along, at the weeds on each side of the path. See if there are seeds on them. Drag a big square of rough cloth, such as an old white woolen scarf, across the tops and sides of the plants as they walk. On returning to the classroom, examine the cloth. Are there any seeds attached to the cloth? How many? How many kinds? Use a magnifying glass to see how seeds became attached to the cloth.

Ask children to discuss how they think furry animals help to scatter seeds far from the parent plant. (Animals' fur picks them up as they brush past plants. Later, the seeds fall off.)

- *Some seeds are scattered when they are hooked on to the fur of animals.*

4. How else do animals move seeds from place to place?

Ask children if they have seen animals carrying seeds in the park or in the country. They may mention the squirrel which buries acorns (seeds of the oak tree) in different places in the soil. Many of these seeds are not found again by the squirrel, and sprout into oak seedlings.

How do birds scatter seeds? Children may recall birds drop seeds from the cherries or berries that they feed on. (In some some cases, seeds which are swallowed by a bird pass out in its droppings.)

- *Animals drop the seeds or fruits that they eat.*
- *Some animals bury seeds in the soil.*

5. In what other ways do some seeds travel from the plants which made them?

Ask children to explain why similar plants are found in places far apart. How did the plants get there? Children may mention that seeds are blown around by air. Ask for examples. Among these will be seeds of the dandelion, maple ("Polly nose"), milkweed, and cattail.

Besides air, what else carries seeds along? Children who have played near lakes and ponds will talk about water lilies. Those who have been in southern areas may recall seeing coconuts floating on water.

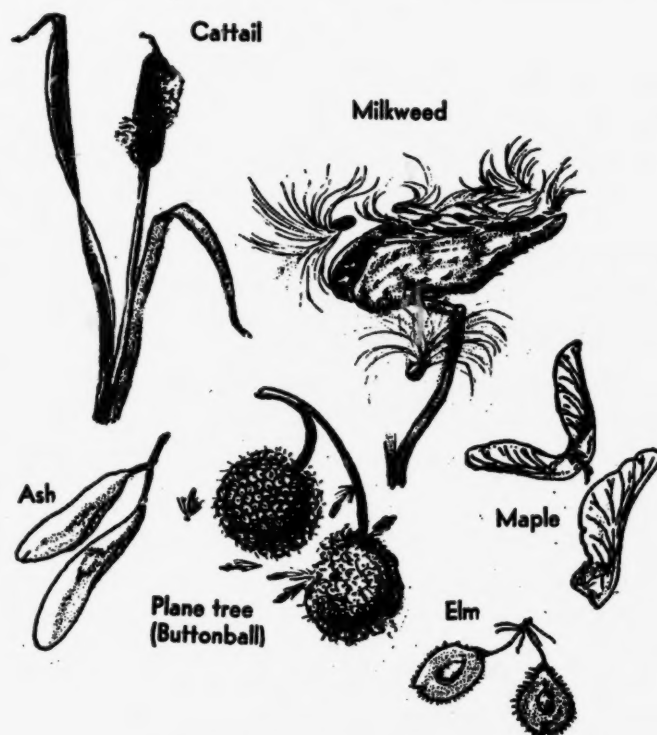
The class may bring in enough examples to make a collection of seeds that move from place to place by different methods. Display them in three trays as follows.

Seeds that are carried by animals.

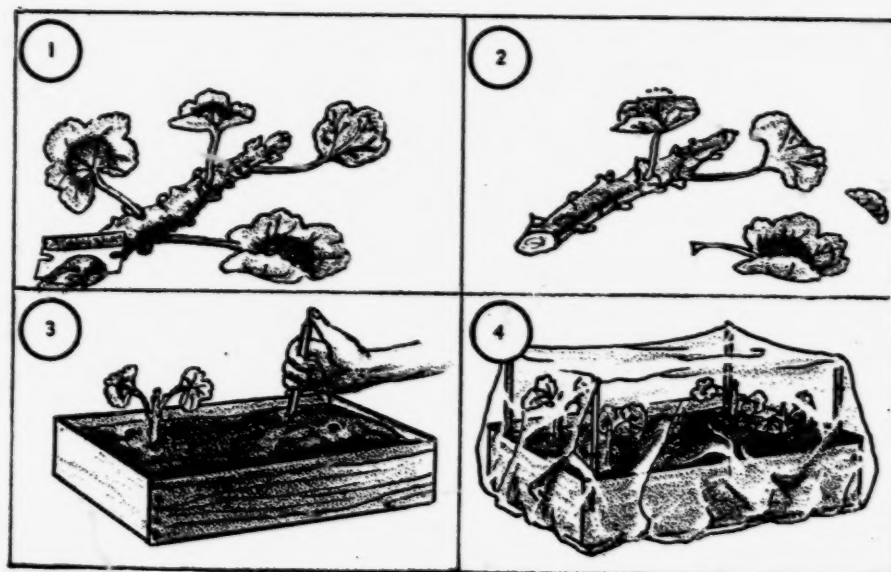
Seeds that are carried by air.

Seeds that are carried by water.

- *Some seeds travel by air, some by water.*



Some seeds travel by air.



Starting geranium cuttings.

6. How can we get more geranium plants without planting seeds?

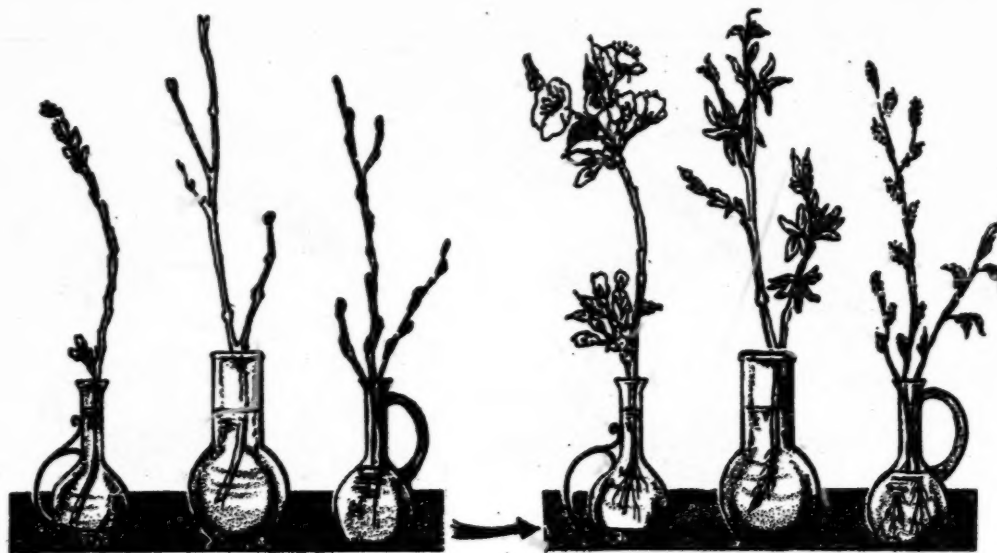
Cut across the stem of a geranium plant a few inches below the tip. From this piece remove all but two or three of the highest leaves, and insert the base of the cut stem in soil, moist sand, or water. If grown in soil or sand, cover the plant with a glass jar or with plastic to maintain humid conditions. Keep the plant out of direct sunlight. The class will observe that some geranium stems develop roots and new leaves. Some stems may rot and die. Ask children to give possible reasons for this.

Transplant the cuttings which are grown in sand or water into soil after a good root system has developed. Try to grow cuttings of coleus, begonia, English ivy, philodendron, and pothos in the same way.

- *The stems cut from some plants can grow into new plants.*
- *These new plants are like the parent plant.*

7. Can a cut pussy-willow stem grow?

Place pussy-willow twigs in water. Observe them as the roots appear and grow. When the roots are about one-half inch long, have the children plant some twigs in moist sand and some in soil. Allow others to remain in glass containers of water, so that pupils can see and compare the number of roots which increase. If possible, transfer some of the plants to an appropriate place on the school grounds, perhaps on Arbor Day. Other woody plants which may be grown from twigs include forsythia and privet. *Note:* Make sure that children understand that they are not to break twigs



Cherry, forsythia, and pussy willow buds open indoors.

or branches off trees or bushes in parks at any time, or elsewhere without permission.

- *Twigs cut from some woody plants will develop roots and grow into new plants.*
- *These plants are like the parent plant.*

8. How can we grow a new potato from an old one?

Discuss with children the fact that the white Irish potato is an enlarged underground stem of the potato plant. The "eyes" are the buds of this stem. Ask them how they can get many more potatoes from the original one. They can plant either the whole potato or chunks of the potato, making sure that each chunk contains at least one bud.

To see how a bud develops each day, have children take two cut pieces of a potato, each with one or more eyes, and plant them in soil in flower pots. In one, only the bud is exposed. Plant the other chunk deep beneath the soil.

Children will be delighted to harvest a few potatoes large enough to eat if they have the patience to wait a few months for them to develop. This may be a good project to conduct in the school garden.

- *We can obtain new potatoes by cutting from an old potato pieces which have buds ("eyes") and planting them.*

9. How can we get more sweet potatoes from this one?

Explain to the children that the sweet potato is the enlarged root of the

GRADE FOUR

plant. Some of them may have seen sweet potato plants growing at home or in a classroom. How is the sweet potato usually set up for growing? What appears out of the top of the potato? What comes out of the bottom? (The secondary roots.) What do you think will happen if we put this plant in good, watered soil? Try it and wait. Also plant a sweet potato in a jar with the lower (pointed) portion submerged in water. The children may find sweet potatoes growing in the form of roots attached to the original one.

- *Some plants can be grown from roots.*



Different ways of starting new plants.

10. Can we grow new plants from leaves?

Place a leaf of "Live Forever" or "Air Plant" (bryophyllum) on sandy soil. This plant may be obtained from botanic gardens or plant nurseries. Keep the soil moist and cover the leaf with an inverted glass. Examine the cut leaf from time to time to see if new plants are appearing. When roots and leaves appear on the tiny new plants, separate them by cutting the original leaf, and then transplant them into soil.

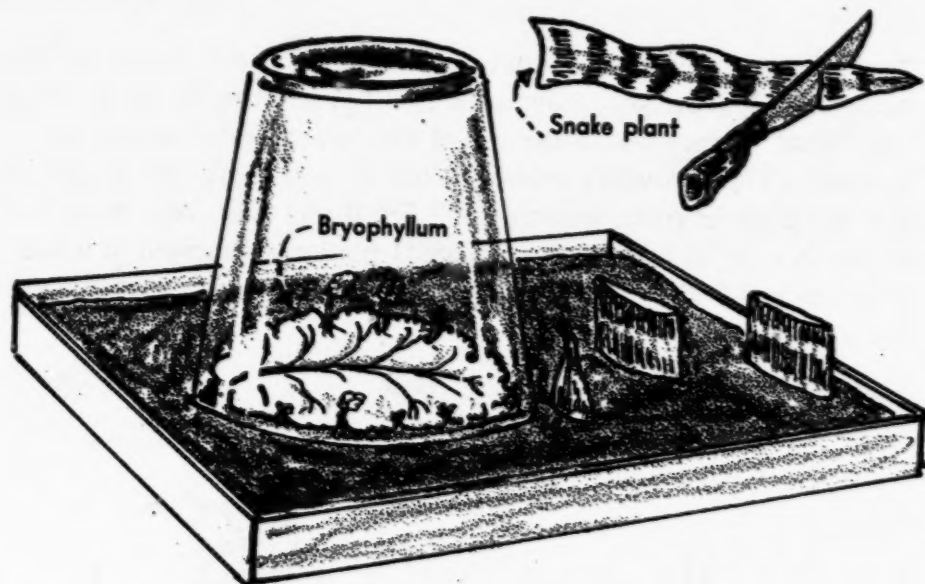
Have the children keep a record as follows.

How long did it take for the new plant to appear?

How many new plants developed from this leaf?

From what part of the leaf did the new plants seem to be growing?

What happened to the original leaf after new plants developed?



Starting new plants from leaves.

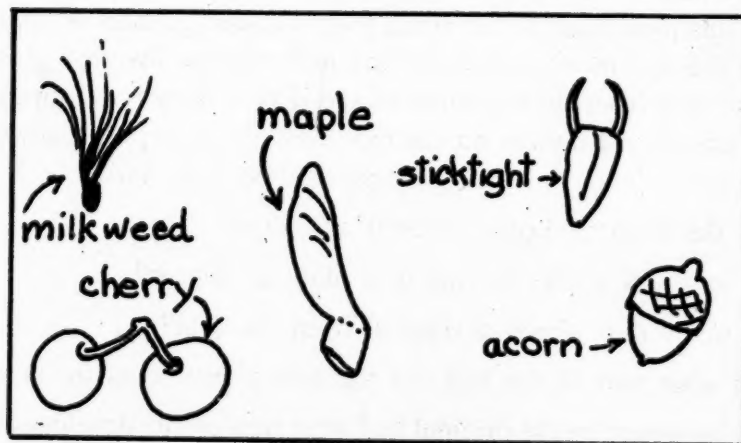
Ask children how they can find out if new plants can be grown from other kinds of leaves. Let them try to do it.

Try to grow new plants from a snake plant by cutting off sections of the leaf and planting them in soil as shown.

- *New plants can be grown from leaves or parts of leaves of some plants.*

EVALUATIVE ACTIVITIES

1. What plants, or parts of plants, in your home right now could you use to start new plants without seeds? How would you make them grow? (Do children think of house plants, potato, onion, sweet potato, and others? Do they suggest appropriate methods for growing them?)
2. How do you think each of the seeds pictured below is scattered? (Milkweed: wind; sticktight: animal's fur; cherry: bird; acorn: squirrel; maple: wind.)



GRADE FOUR

3. What seeds could you find in your home right now? (Do children think of seeds of oranges, grapefruit, watermelon, cherries, tomatoes, green peppers, birdseed, seeds in seeded bread?)
4. Many years ago a volcanic island in the Pacific (Krakatoa) blew up. All plants and animals on it were killed. Years later it was found that the island was again rich in plant life. How did this happen? (Seeds were carried there by water, by wind, and by birds' droppings.)
5. A boy who was trying to find out about the scattering of seeds dragged a blanket across a field. Many seeds stuck to it. What information could be obtained from this? (The kind of seeds that "hook" on to animals; the ways in which seeds are able to "hold on.")
6. A boy sees a man pruning a tree by cutting small branches off it. He picks up some of the twigs and decides to put them in a jar of water. What might happen in a few weeks? (Roots might grow from the cut end of the twig; leaves may appear later.) How might the boy start a new tree with one of the branches? (Place it in soil after roots appear; water it regularly and keep it in sunlight.)
7. How would you set up an experiment to find out whether soaking some pumpkin seeds before planting them would make a difference in how they sprout? (Soak 10 or more unroasted pumpkin seeds for a specified period of time; plant them. Plant the same number of *unsoaked* seeds at the same time. Keep both groups under identical conditions. Observe and record.)
8. A class had two similar flower pots containing the same kind of soil. In one pot they planted four lima beans, about 1" deep in the soil. In the other pot they planted four of the same beans about 2" deep in the soil.

Both pots got identical treatment. The class watched both plants for a month. What was the class trying to find out? (How well seeds sprout when planted at different depths.)
9. Sixteen radish seeds were planted one inch apart in a box containing garden soil. In another box of the same size, sixteen of the same kind of radish seeds were planted in garden soil at the same depth as those in the first box, but in the second box the seeds were planted $\frac{1}{2}$ " apart. The same conditions of sunlight, heat, air, and water were given to both boxes. In two weeks, plants in the two boxes were compared for size and health. Why do you think this experiment was done? (To find out whether crowding or spacing makes any difference in how seeds sprout and in how the seedlings grow.)
10. Six lima beans were placed in a deep-freeze refrigerator for one week. The beans were then removed and each one was planted separately in a large pot that was labelled "Frozen." At the same time, six unfrozen beans from

the same source were planted in another pot which was labelled "Not Frozen." Every planting condition was the same for all 12 beans. A class watched the plants for one month. What were they trying to find out? (Whether freezing beans before planting makes a difference in how the seeds sprout.)

B. LEARNING MORE ABOUT GETTING NEW PLANTS

Interested students may wish to experiment with plants in some of the ways suggested below.

1. Set up an experiment to determine what happens when seeds are planted at varying depths.
2. Set up an experiment to compare what happens when seeds are planted close together and when they are more widely spaced.
3. Will seeds sprout and develop when they are kept completely under water?
4. Set up an experiment to find out whether seeds sprout better in a refrigerator or when kept at room temperature.
5. Plan a class plant show. Include plants children have grown from seeds, bulbs, leaves, stems, and roots (sweet potato). Label each with name and origin (seed, bulb).
6. Sprout five different kinds of seeds. Plan an exhibit to show likenesses and differences in the ways in which these seeds change as they germinate and begin to grow.

BASIC SUPPLY LIST FOR GETTING NEW PLANTS

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- 2 hand Magnifiers
- *10 lbs. Soil
- *10 lbs. Sand
- *1 roll of Cellophane Tape
- *10 Flower Pots
- *4 Flats for starting plants
(metal or polystyrene Trays)

GRADE FOUR

G-1: General Supply List

*4 Dowels

*1 Sprinkling Can

Miscellaneous

*1 dull Knife

*assorted Fruits
(apples, pears, grapefruit,
oranges)

*assorted collection of Seeds
that travel by land, sea,
and air

*assorted Seed pkgs.

*1 Seed Catalog

*1 old white woolen Scarf

*Privet branches

*Forsythia branches

*Pussy Willow branches

*2 large "tin" Cans

*4 glass Containers

*4 Potatoes with "eyes"

*2 Sweet Potatoes

*1 Bryophyllum plant

*1 glass Tumbler

**1 Geranium plant

**1 Snake plant

**1 Coleus plant

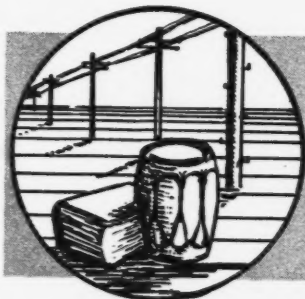
**1 Begonia plant

**1 English Ivy plant

**1 Philodendron plant

**1 Pothos plant

**May be purchased from the School Garden Association of New York



Sounds Travel; Sounds Can Be Recorded

A. SOUNDS ARE CARRIED BY AIR AND BY OTHER MATERIALS

Background for the Teacher

To be heard, a sound must travel from where it originates to our ears. *The Background for the Teacher*, Grade 3, explains how vibrating objects produce sound. These vibrating objects push against nearby air molecules causing them to move, first close together and then farther apart. *Compression* is the term used to indicate that molecules are close together; *rarefaction*, to indicate that they are more widely separated. As the vibrating molecules push one another, *sound waves* are formed which travel away from the vibrating object in all directions.

The air is not an obstacle that sound must bypass to reach us. The molecules of air form the sound waves which carry the sound from vibrating objects to our ears. Sound cannot travel in a vacuum, since a vacuum contains no molecules to carry the wave.

In air of 32°F., sound travels about 1100 feet a second, or a mile in about 5 seconds. In warmer air, molecules vibrate more rapidly and the sound wave travels faster. Air, of course, is a gas. In liquids, the molecules are closer together than in a gas and they vibrate more rapidly and carry sound faster. In solids, molecules are very close together and carry sound very quickly.

When sound waves hit a large, solid surface such as a wall, they bounce back. If we are at least 55 feet away from the reflecting surface, we hear this reflected sound as an echo. If we are less than 55 feet from the reflecting surface, the sound waves bounce back so fast that they blend with the original sound.

Approaches and Learnings for the Child

Children are aware that sound can be heard from a distance. Now they are ready to discover that sound travels and that a material is needed

to transmit it. Through a series of observations and investigations, the children find out that different kinds of materials can carry sound from place to place.

From the activities suggested, children learn the following.

Sound travels from one place to another.

Sound travels through air, through water, and through solids.

Sound can be controlled in many different ways.

Sound can be reflected from a surface.

Sound travels much more slowly than light.

An echo is a reflected sound.

1. Can sound travel through a tube?

By experimenting with a 20-foot length of garden hose, children discover that sound can be piped from one place to another, just like water. The hose may be borrowed from the school custodian. (A tube may also be made by rolling overlapping sheets of newspaper and taping them together.)



If one end of the tube extends to the hall outside the room, a child there may communicate with a listener in the classroom. The speaker should whisper or talk very softly and the listener should communicate the message to the class. To check the action of the tube, the child in the hall should whisper or talk in the same tone without using the tube. Can he be heard now?



The tube helps in the transmission of sound with little loss of volume (loudness) because it prevents the sound from scattering in all directions. Encourage the children to suggest different experiments with the tube. They may want to place it in different positions; to shape the tube in different curves; and to bend it so sharply as to close the tube.

Speaking tubes were used before the invention of the electric telephone. They were common on ships, where they served as a means of communication between the pilot and the engineer. Speaking tubes were also used between various parts of large houses.

Children may be interested in the experiment conducted by the French scientist, Jean Baptiste Biot. He used the water pipes of Paris at a time when all the water had been drained out of them. He found that he could hold a conversation in a low voice through 3,120 feet of these iron tubes. The lowest possible whisper could be heard at this distance. The firing of a pistol into one end of the tube quenched a lighted candle at the other end.

- *Sound travels from one place to another.*
- *Sound travels through air.*
- *Sound travels better through a tube than in the open.*
- *Sound can travel around corners.*



A working model of a stethoscope.

2. How can we detect quiet sounds?

A working model of a stethoscope can be made with a piece of rubber tubing about three feet long with a funnel fitted into one end of it. The funnel end is placed close to a quiet sound and the other end is brought to the ear. Determine the effectiveness of this sound detector by listening at the same distance without the device. Ask the children to suggest a number of uses for their sound detector. These may include listening to

- a radio played so softly it cannot be heard under ordinary conditions
- a ticking watch

someone whispering into the funnel

an insect in a box

an electric refrigerator

someone talking softly (place funnel against throat).

The sound detector works because the funnel collects sound from a wide area and conducts it through a tube to the ear. Thus the volume of the sound, instead of being scattered in all directions, is gathered and brought to the ear.

- *We can hear quiet sounds by collecting them in a funnel and guiding them to our ears.*
- *The doctor's stethoscope helps him hear a heart beat more easily.*

3. Why do people use a megaphone?

Have the children make several megaphones by rolling oaktag into a short, wide cone or funnel. Each megaphone should have a small opening at one end and a broad opening at the other end. Megaphones may be made in different sizes, and from different kinds of paper and light cardboard.

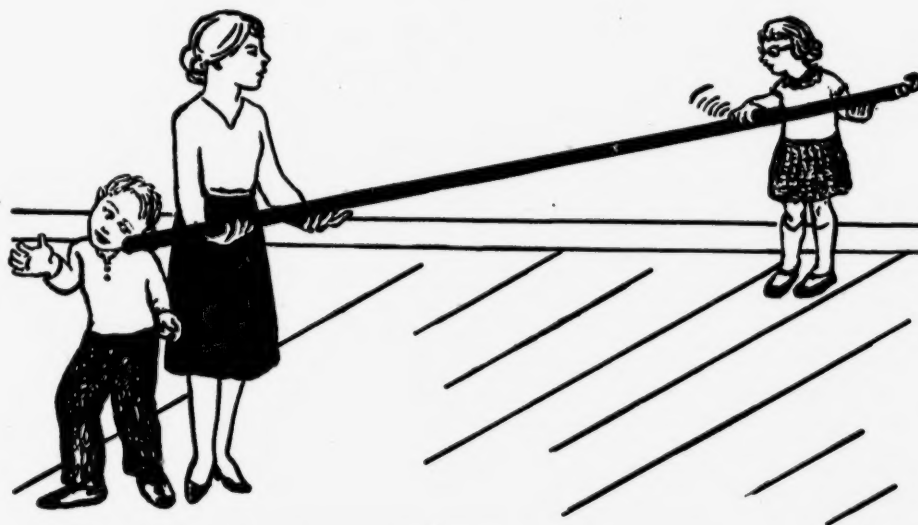
Allow one child at a time to use a megaphone. Let him talk into it facing toward and then away from the class. What is observed in each case? The class will notice that the sound is louder when the megaphone is turned toward it, and softer when the megaphone is turned away.

Ask a pupil to face the class and talk in a normal voice. Then ask him to speak as before, but through a megaphone. The children will observe that the sound seems louder when a megaphone is used. This activity may be varied and repeated in different ways, using megaphones of different sizes and materials.

- *Sounds can be directed.*
- *Sounds can be made louder in one direction by concentrating them in that direction.*

4. Why did people in early times "keep an ear to the ground"?

In early times, people would put an ear to the ground to listen for the hoof beats of distant horses. This was effective because, as we have learned, sound goes through most solids better than it does through air.



Sound travels through a window pole.

Children can discover this for themselves by tapping their fingers lightly on one end of their desks—so lightly that they cannot hear the sound. If they then place their heads on their desks while tapping, they will hear the taps very distinctly.

Also use a window pole or yardstick instead of the desk. Have the children investigate how the sound is transmitted through such things as the chalkboard, the wall, the chalk rack, pipes in the room, metal cabinets, and the floor.

- *Most solids are better conductors of sound than air.*
- *We can hear, through solids, sounds we could not detect otherwise.*

5. Can sound travel through a string?

The end of a piece of light string (about 12" long) is tied to the waist of a spoon. The other end is held between the thumb and forefinger so that the spoon hangs free. (See page 156.) If the spoon is tapped with a pencil, the children will hear chime-like sounds. The children should understand and state that the sound traveled from the spoon, through the air, to the ear. As each child tries this, he will feel the vibration in the fingers holding the string. This vibration becomes stronger when the spoon is tapped harder. Some children may suggest holding the string to one ear. They will be surprised to hear a loud bell-like clang. In this case, the children will note and be able to trace the path of the sound from the spoon through the string to the ear. If both ears are used, as shown in the illustration, the sound heard is even louder. For this experiment a one-inch loop is tied in each end of a three-foot length of light string in the center of which the spoon is suspended.

A forefinger is placed through each of the end loops and is pressed against the tragus, closing the opening to the ear. The listener leans forward and allows the spoon to strike the edge of the desk. After they have tried this, help the pupils trace the course of the sound from spoon to strings, to fingers, to ear.

- *Sound can travel through a string.*
- *Sound can travel through a finger.*
- *Sound is louder when carried from a vibrating spoon along a string to our ears, than when carried from the spoon by the air.*
- *When a string carries sound, the string vibrates.*

6. How could you signal a friend who is underwater?

Children may recall an experience of clicking stones together while under water and hearing the sound. How is this possible? (Sound travels through water.) How can we prove, here in our classroom, that sound travels through water? Children may suggest something like the following. Fill an aquarium with water. Take two pieces of metal or rock and hit them together under the water. Children will hear a clicking sound. What is the path of the sound? (From the rocks, through the water, through the aquarium, glass, through the air, and to our ears.)

Ask a child to place his ear against the side of the aquarium while two rocks are struck under water. How does this sound compare with the one that was previously made? (It is louder.)

- *Sound travels through water.*

7. How can we make a string telephone?

A usable "telephone" can be made from two sturdy paper cups and a piece of strong, thin string about 20 feet long. A small hole is punched in the bottom of each cup. The string is inserted through the holes from one cup to the other. At each end of the string, a knot held in place by a piece of toothpick, match stick, or other suitable material, is tied inside each cup. The partners in the "telephone" hook-up stand far enough apart so that the string is kept tight (taut). The string must not touch any object while the "telephone" is in operation, to insure vibration and, therefore, maximum communication effectiveness.

Encourage pairs of children to try various experiments with this device. They may want to find out what happens when the string is loose,

or when the string touches something, or when the string is pinched in the middle by a third child. They may want to feel the string with their fingertips (ear lobes, lips) while they are talking, to try to detect vibrations. Some children may wish to make "telephones" with other things such as tin cans, milk cartons, oatmeal boxes or plastic containers. Wire, nylon, fishing line, and similar materials may be used instead of string.

Ask the children to trace the path of sound in a string telephone. They may include the following.

The sounds from the talker make the air in the container vibrate.

The vibrating air makes the sides and bottom of the transmitting container vibrate.

The vibrating bottom of the container makes the string vibrate.

The vibrating string makes the sides and bottom of the receiving container vibrate.

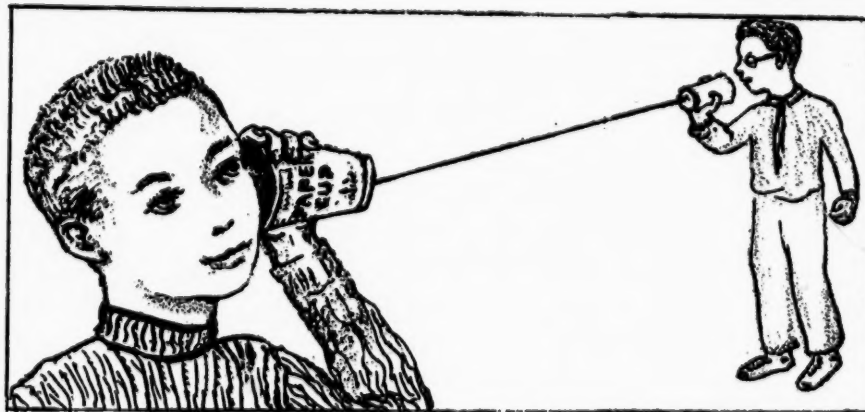
The vibrating air makes the listener's eardrum vibrate.

Note: The telephones in our homes differ from the string "telephone" in that the sound vibrations themselves are *not* transmitted by the wires. In home telephones the following occurs:

Sound causes vibrations in a small disc in the telephone transmitter (mouthpiece).

The vibrations cause a varying electric current to flow through the telephone wires.

The varying electric current causes another disc, in the receiver, to vibrate in the same way the first disc vibrated, thus reproducing the original sound.



Sound travels through a string.

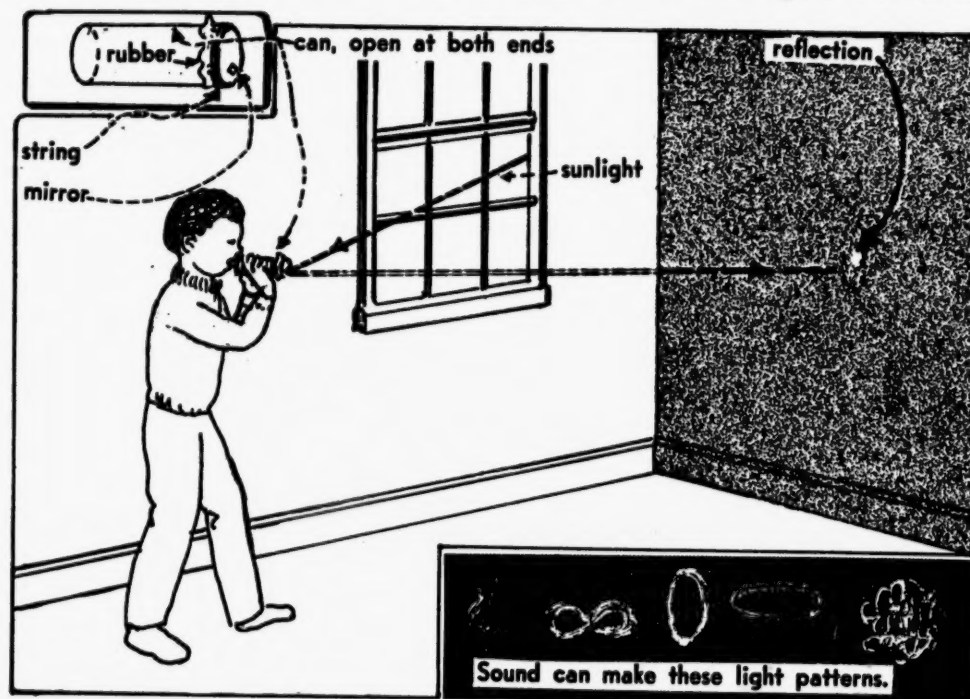
- Sound travels from one place to another.
- Sound can travel through air and through solids such as paper and string.
- When an object carries sound, the object vibrates.

8. How can you "see" the sound of your voice?

A simple *oscilloscope* can be constructed to demonstrate how various sound patterns can be projected as vibrations and cause a spot of light to dance on a wall.

Obtain a small tin can which has been opened. Use a can opener to remove the other end without leaving any jagged edges. Stretch the bottom half of a toy balloon over one end of the can, as on a drum. Use string or rubber bands to hold the rubber sheeting in place. From a small pocket mirror cut a piece about $\frac{1}{4}$ inch square. If you cannot get someone to cut it for you, then carefully break the mirror in a paper bag. Select a small, suitable piece. Glue this, mirror side up, on the rubber membrane about one-third of the distance across its diameter.

Have a child hold the can with the open end near his mouth and stand where a bright beam of sunlight will be reflected from the tiny mirror, as a spot of light on the wall. Or, if you wish, another child may hold a small white cardboard so as to catch the reflected spot. The child



"Seeing" the sound of one's voice.

holding the can should place his mouth close to its open end and make singing sounds. Notice the different patterns which are formed. Among the shapes will be ovals, figure-eight loops, lines, and also combinations of curves and lines.

Vibration of the vocal cords causes the air in the can to vibrate. The vibration is transmitted to the membrane and the attached mirror. The sunbeam reflecting from the vibrating mirror produces the patterns seen on the wall or card.

Have the child using this *oscilloscope* repeat each singing sound several times, using sounds such as *eh, ah, oh, oah, ay, au, eye*. Children will note that the pattern of each sound has its own characteristic shape. Ask the child to sing louder. What happens to the size of the pattern? Try using a softer sound and observe results. Children may want to keep a record of their findings.

Encourage children to experiment with this sound apparatus. Suggest rotating the can, for instance, while sounds are being made. Are the shapes different as this is done? Children may want to vary the size of the can, the tightness of the rubber sheeting, and the location of the mirror on the membrane. What happens when the mirror is placed exactly in the center? What shapes will you get if you glue two mirrors on the rubber in different places?

This oscilloscope can be used in a dark room by shining a flashlight beam on the mirror. Notice that the farther away one is from the screen, the larger the pattern becomes. However, the reflection also gets dimmer. Ask for a volunteer to report on an electronic oscilloscope, the kind used by scientists and engineers.

- *Sound vibrations may be made visible.*
- *Patterns are different when the tones are different.*



9. Why do we see lightning before we hear thunder?

A thunderstorm during the school day may motivate this question. Ask the children to observe closely and to report what happens during a thunderstorm. They may report as follows. A flash of lightning is followed by a clap of thunder. Sometimes the interval between the flash and the clap is long; sometimes the interval is short. The sound of thunder may cause the house or building to shake as the sound waves press against it.

The following steps in the discussion of this phenomenon will help to clarify it for children. They should first be aware of the following facts.

Lightning is the flash caused by the streaking of electricity (a huge electric spark) through the air between cloud and cloud or cloud and earth.

The lightning bolt heats the air around it; the resulting sudden expansion of the air starts a sound wave which reaches our ears as thunder.

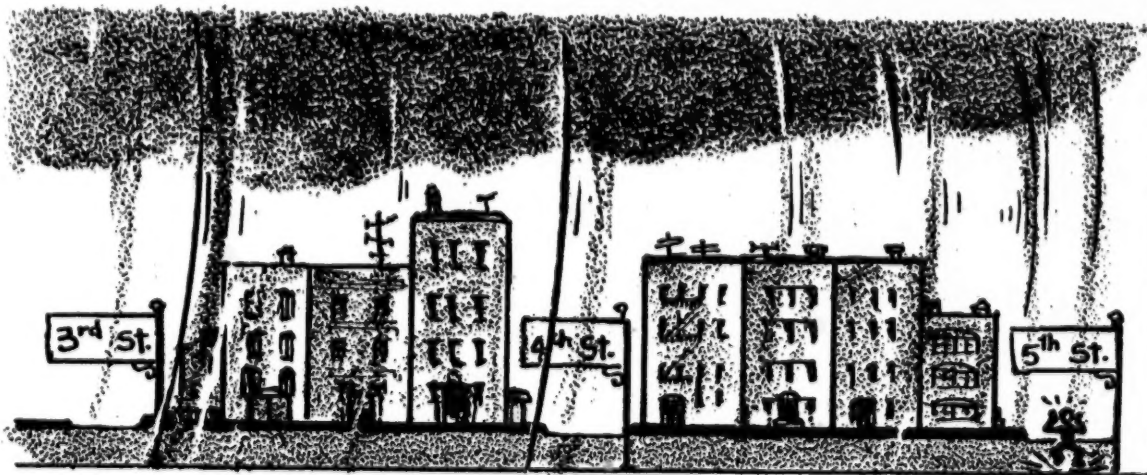
The light of the flash gets to us almost at once, but the sound takes longer to make the trip.

Next, from the previous study of sound, review the following understandings.

Sound is caused by vibrations.

Sound travels from place to place.

Then, ask for examples of *seeing* an occurrence before hearing it. Some children may recall watching from a distance as a man chopped wood, and hearing the sound after seeing the axe strike the wood. Other examples may include:



watching from a distance as a batter hit a baseball, and then hearing the "crack"

seeing a puff of steam from a boat whistle before hearing the sound

seeing a pile struck by a pile-driver before hearing the sound

seeing a fireworks display explode into color before hearing the sound of the explosion.

From these observations, children may propose the tentative theory that light travels faster than sound. This might be a good opportunity for children to prepare a brief report on what scientists have discovered about the speed of sound and light. (Sound travels about one mile in 5 seconds. Light, on the other hand, travels about 186,000 miles in one second. This is equivalent to traveling $7\frac{1}{2}$ times around the earth at the equator in one second.)

Children may be interested in one of the early ways of measuring the speed of sound, discovered in 1823 by two Dutch scientists, Van Beek and Moll. A cannon was fired from a high hill. Its flash and its roar were observed from another hill eleven miles away. The time between the flash and the roar was noted. From these observations, it was possible to calculate the speed of sound: about 760 miles per hour.

During a thunderstorm, children can find out how far away a flash of lightning is. Use a watch with a sweep-second hand to time the number of seconds between the flash and the thunder. Since sound travels one mile in 5 seconds, it will travel $\frac{1}{5}$ of a mile in one second. Therefore, if you determine the number of seconds between the flash and the first noise and divide that number by 5, the resulting number will give the distance in miles. For example, if the time interval is ten seconds, the flash is about two miles away.

Children will want to tell of jet planes which travel faster than sound (that is, faster than about 760 miles per hour.)

- *Thunder and lightning occur together, but we see lightning first.*
- *Sound travels much more slowly than light.*
- *Sound travels about $\frac{1}{5}$ mile a second (about four city blocks) in air.*

10. Do sea shells have the sound of the sea in them?

Some children believe that the roar they hear in a large sea shell is a sound which the shells picked up from the ocean. Raise the question, "How can we find out whether this belief is true or not?"

Some children may suggest listening to hollow objects other than sea shells to ascertain whether a similar sound is heard.

Have children hold sea shells to their ears. Then have them do this with other hollow objects, such as drinking glasses, jars, pitchers, ice cream containers and milk cartons. Children will find that these hollow objects, which may never have been near the sea, also "roar."

Call a pupil to the front of the room. Ask him to close his eyes. Hold a sea shell close to his ear, then a drinking glass and then other hollow objects, including the same or other shells. Ask the pupil which one is the shell and which one is not. If the shell and the other objects are presented in no special order, he will probably be unable to tell them apart.

- *Other hollow things, as well as sea shells, may sound noisy when we listen at an opening.*

11. What makes the sound in hollow objects?

Collect the hollow objects available, including sea shells. Pass these out and suggest that the children listen to them and exchange them with each other, so that everyone gets a chance to listen to several of them. Close the windows and doors. Ask the class to become very quiet and listen again to the hollow objects. The children will discover that when the room is quiet the amount of sound coming from the hollow objects lessens. As the level of sound in the room increases, the roaring noise from the shells and other hollow objects becomes louder. The children may then be able to suggest that the sounds in the room give rise to the sounds in the sea shells or other hollow objects.

- *The sounds from a hollow object are louder in noisy places than in quiet places.*
- *The sounds we hear when listening to hollow objects come from the sounds all around us at the time we are listening.*

12. What makes echoes?

Ask children to discuss their experiences with echoes. Many of them will recall having heard echoes when directing their voices toward a wall, tunnel, underpass, cliff, hillside, or steep river bank. Ask how echoes are made. When a ball is thrown against a wall, what happens to it? Discussion should bring out that sound is reflected ("bounces") from a surface just as is a rubber ball. When sound waves strike a hard surface, they bounce back. If they do, we may hear the sound repeated. We say

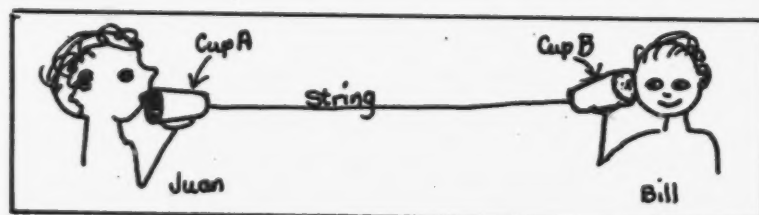
we hear an echo. An echo is not as loud as the sound that made it. Have children try to produce echoes by shouting in an empty auditorium, gymnasium, or outdoors near the wall of a building.

There must be at least about a tenth of a second between two sounds for humans to recognize them as two separate sounds rather than one prolonged one. This means that an echoing surface must be at least 55 feet away from the listener since the round trip to the surface and back (110 feet) will take about a tenth of a second. If the distance is less than 55 feet, the reflection, instead of being distinct and separate, will simply prolong the sound. This is called reverberation. Small empty rooms reverberate by reflecting the sound from wall to wall.

- *Sounds can be reflected from a surface.*
- *An echo is a reflected sound.*

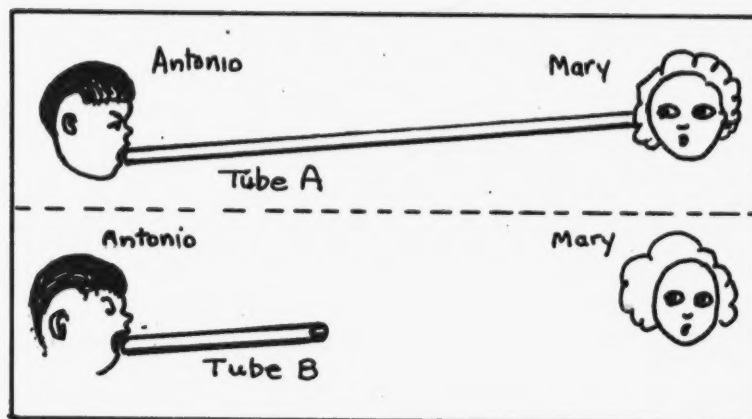
EVALUATIVE ACTIVITIES

1. In each case, tell whether the sound travels through air, a solid, or both, in order to reach the ear.
 - a. The children heard the teacher who was at the front of the room. (Air.)
 - b. The cheer leader used a megaphone to speak to his team. (Air.)
 - c. The man heard his neighbor signal to him by banging on the steam pipe. (Both —solid, then air.)
 - d. The Indian put his ear to the ground to listen for the hoof beats of horses that were far away. (Solid.)
 - e. The children heard a bird that was singing in the tree. (Air.)
 - f. When Carlos put his ear to the wall he could hear what his brother was saying in the next room. (Both—air, then solid.)
2. Juan and Bill are using a string telephone. They can hear sound with it because parts of it vibrate. Trace the path of the vibration from Juan to Bill using the following words in their correct order: string, air in Cup B, air in Cup A, Cup A, Cup B. (Air in Cup A; Cup A; string; Cup B; air in Cup B.)



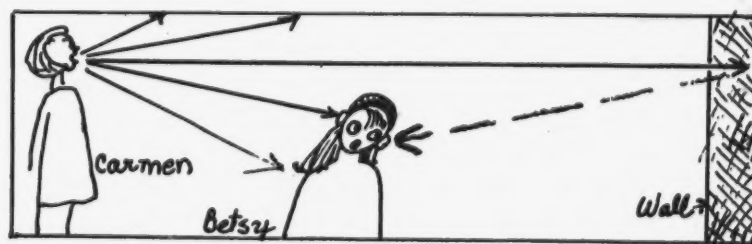
3. Pictured next are two tubes. If Antonio spoke through each, which would cause his voice to seem louder to Mary? (A.) Explain why. (In A, most of the

GRADE FOUR



sound is kept in the tube all the way to Mary; in B, the sound spreads out at the end of the tube.)

4. Explorers on the moon will not be able to hear each other across space no matter how loudly one shouts to the other. Explain why. (On the moon, there is no air through which the sound can travel.) How will moon explorers be able to talk to each other? (By radio or walkie-talkie, built into their space suits.)
5. Joe was alone outdoors. He shouted at a faraway cliff. A short time later he heard his shout repeated. What may have caused this? (A friend yelled back; or, he heard the echo of his voice.)
6. Carmen and Betsy are standing in an empty gymnasium. Carmen calls to Betsy. Betsy hears each word *twice*. In the drawing below, one line shows the path of the first sound Betsy hears. Add the lines which show why Betsy heard it a second time. (The answer is shown by the dotted lines *to be added by the pupil*.)



7. David watched Henry bang a drum about two blocks away from where he was standing.
 - a. David heard the sound when the drum stick was on its way up from the drum. Why? (It took longer for the sound to reach David than for the light patterns.) About how long did it take the sound to reach David? (One-half second.)
 - b. Henry heard an echo of his own drumming bounce back from a wall behind David. How long did it take between the hitting of the drum and

the hearing of the echo? (About one second, because it had to travel to the wall near David and then back to Henry.)

8. Martin and Alfred made a string telephone, but they found they could not hear each other over it. Why? How many reasons can you think of?

(String is too loose; string is touching something which stops the vibration; the sound made by the speaker is too weak; there are too many other sounds in the room.)

9. Jules made an oscilloscope. He made sounds into it and then we were able to see the patterns made by the vibrations of his voice.

The sound of his voice caused these things to happen.

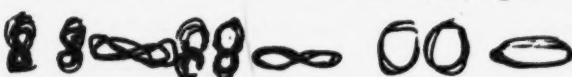
The rubber vibrated.

The mirror on the rubber moved.

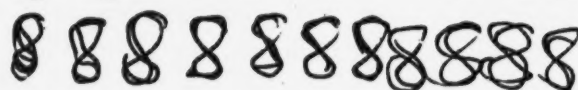
The reflection from the mirror moved.

When Jules spoke loudly, the reflection was bigger. When the tone of his voice changed, the pattern of the reflection changed. Pictured below are some of the reflections as seen on the oscilloscope.

Which showed loud sounds? (B.) different tones? (A.) quiet sounds? (C.)

A. 

B. 

C. 

B. SOUNDS CAN BE RECORDED FOR FUTURE USE

Background for the Teacher

Sounds are preserved by impressing their vibrations on a phonograph record. Thomas A. Edison made the first record by wrapping tinfoil around a cylinder and having a needle run over the rotating cylinder in a spiral path. The needle was attached to a diaphragm (a thin metal disc) which was placed across the narrow end of a megaphone. Edison spoke into the megaphone. His voice made the diaphragm and the attached needle vibrate, causing wavy lines in the tinfoil. When the record was re-run, the sound of his voice was reproduced quite well, providing that the record was played back at the same speed as that at which

it was recorded. Modern records are made with elaborate equipment but the same basic principles apply.

When a phonograph record is examined under a magnifying glass it becomes apparent that its grooves are not regular, but wavy. A needle moves along the wavy grooves and is made to vibrate. The sounds caused by these vibrations are then amplified so that they can be heard. Early phonographs used a megaphone or horn for this purpose. With the advent of radio tubes, amplification and reproduction of the sound were improved. Modern hi-fi and stereophonic instruments make listening to a recording almost the same as actually hearing the original performance.

Approaches and Learnings for the Child

The work on sound thus far has developed the ideas that sounds differ and are produced in various ways, that sounds may be controlled, and that sounds are always caused by the vibration of matter. Now attention is directed to the recording of sounds. By experimenting with a phonograph record, the child comes to understand how it works. He sees the tiny waves or wriggles in the record. He learns that these wriggles are a record of the vibrations of the original sound. He discovers that the turning record makes the needle vibrate to make sounds.

From the activities suggested, children learn the following.

Sounds are preserved by impressing their vibrations onto a turning record.

The vibrations carve wavy grooves in the record.

In playing the record, the wavy grooves cause a needle to vibrate and to reproduce the sound.

1. How does a phonograph record produce sound?

The activities suggested below develop two main ideas. First, a record produces sound by causing a needle to vibrate; and second, the sound can be made louder (amplified) by connecting the needle to a larger surface which is free to vibrate.

Have a child hold a straight pin, as illustrated (a), so that its point rides in the grooves of an old 78 r.p.m. record which is turning on a record player. He tells what he sees, feels, and hears.

To make the sound louder, insert the pin through the corner of a card (b). Play the record again. The children will notice that the sound is louder. To make the sound still louder, put the pin through the end of a paper cone (c). (In a modern electric record player, the vibrations of the needle are changed to electric currents which operate the speaker.)



Which is loudest?

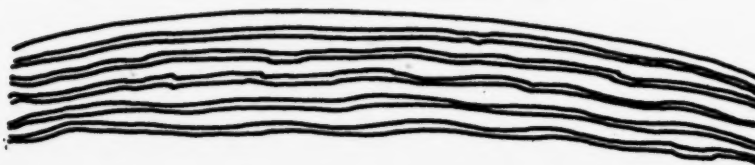
- *A record produces sound by causing a needle to vibrate.*
- *By attaching the vibrating needle to a larger surface, the sound can be made louder.*

2. Can we see what causes the needle to vibrate?

With a strong magnifying glass, look at the grooves of a 78 r.p.m. record. Tilt the record one way and another, so that the light falls on it from different angles. Pick out the wavy lines which make up the grooves. It will be apparent that, as the needle moves in the grooves, it is shaken (moved) back and forth by the wavy lines. Another way to see the grooves is to make an imprint, using non-hardening clay. Press a piece of Plasticine against the record, lift it up and off carefully, and examine the imprint with a magnifying glass.

- *The grooves of a phonograph record are wavy.*
- *The waves wiggle from side to side.*
- *The waves cause the needle to vibrate.*

EVALUATIVE ACTIVITIES



1. This is part of the grooves in a phonograph record, magnified.
 - a. How can you tell, without playing the record, that it can make sound? (There are waves in the grooves.)
 - b. How could you *prove* that it can make a sound? (Play it; turn the record with a needle in it.)
 - c. What does a record do to the needle? (Makes it vibrate.)
 - d. How do you think the first few outside grooves of a record look? Draw them. (Smooth, no waves.)

C. FINDING OUT MORE ABOUT SOUND

The following questions, problems, and suggestions are meant for children with an unusual interest or ability, who may wish to pursue the subject further. It is not intended that the questions be specifically answered but rather that they serve as leads for additional research and discussion.

1. How will space explorers on the moon talk to each other?
2. Is there a place in our school or neighborhood where echoes can be heard?
3. How are phonograph records made?
4. How are sounds recorded on magnetic tape? On sound films?
5. How does *sonar* help ships at sea detect other ships and underwater obstacles?
6. How are bats able to fly in total darkness without striking objects?
7. What is unusual about the sound of a dog whistle?
8. Do animals that live in the sea make sounds?
9. From how far away can you hear the sound that reaches you through an iron railing along a park wall?
10. What difference in sounds do you notice between those heard in a furnished and those heard in an empty room?
11. How are rooms soundproofed?
12. Why does a doctor use a stethoscope?
13. Rub a wet finger around and around against the rim of a thin glass. Can you produce a sound?
14. Why do we "cup" our ears?
15. Why does a cheerleader use a megaphone? What does a megaphone do? How does a "bull horn" help to project the voice?

BASIC SUPPLY LIST
FOR SOUNDS TRAVEL; SOUNDS CAN BE RECORDED

*Indicates quantity for entire class; other quantities
specified are for each group of 4 children.

E-1: Science Supply List

- | | |
|---------------------------------|-------------------|
| 2 Funnels | *1 Hand Mirror |
| 2 rubber Tubes, each 3 ft. long | *1 bottle Glue |
| *1 Aquarium | *1 Flashlight |
| *2 Wires, each 20 ft. long | 2 hand Magnifiers |
| *1 rubber Sheeting | |

G-1: General Supply List

- | | |
|-----------------------------------|----------------------|
| *1 roll Cellophane Tape | *1 ball String |
| 4 sheets small Oaktag | (warp, thread white) |
| 4 sheets small Construction Paper | 2 Teaspoons |
| *1 Yardstick | 2 Pencils |
| *1 Window Pole | 4 paper Cups |
| *1 Projection Screen | 4 Rubber Bands |
| *1 small rubber Ball | *1 Record Player |
| 4 straight Pins | 4 Index Cards (3x5) |

Miscellaneous

- | | |
|---------------------------|----------------------------------|
| *1 Fishing line, 20' long | 2 paper Bags |
| 4 Ice Cream Containers | *1 pkg. Plasticene |
| 2 small Tin Cans | *Assorted tin cups, seashells, |
| *1 old 78 RPM Record | pitchers, drinking glasses, jars |
| *1 garden Hose, 20' long | *1 sheet white Cardboard |
| 2 Newspapers | *10 Toothpicks |
| *2 medium size Rocks | 4 Milk Cartons |
| | *1 piece nylon String, 20' long |



Weather and Climate from Season to Season

A. THE SEASONS

Background for the Teacher

In New York City there are wide variations in weather patterns during the year, ranging from hot summers to cold winters. The full (and predictable) cycle of the four seasons—spring, summer, fall, and winter—is the result of New York's 41° N. latitude which places the city in the North Temperature Zone. People living in the extreme zones, Torrid and Frigid, experience fewer seasonal changes than do those in the middle zone.

Basically, seasonal changes are caused by three astronomical factors.

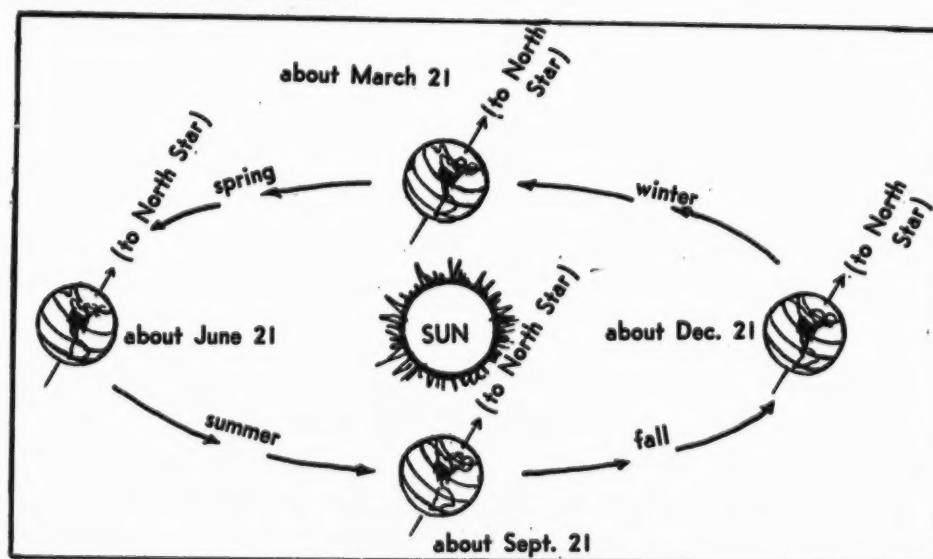
In the course of the year the earth revolves in an orbit around the sun.

The earth's axis is tilted $23\frac{1}{2}^{\circ}$ from the vertical with reference to the plane of its orbit.

The earth's axis always points in space toward the North Star.

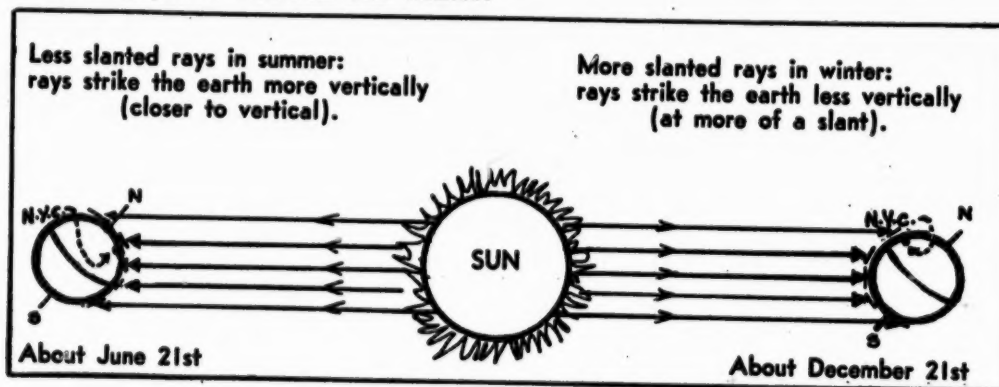
A study of the illustrations highlights the following points.

The northern hemisphere is tilted toward the sun in our summer, away from the sun in our winter.



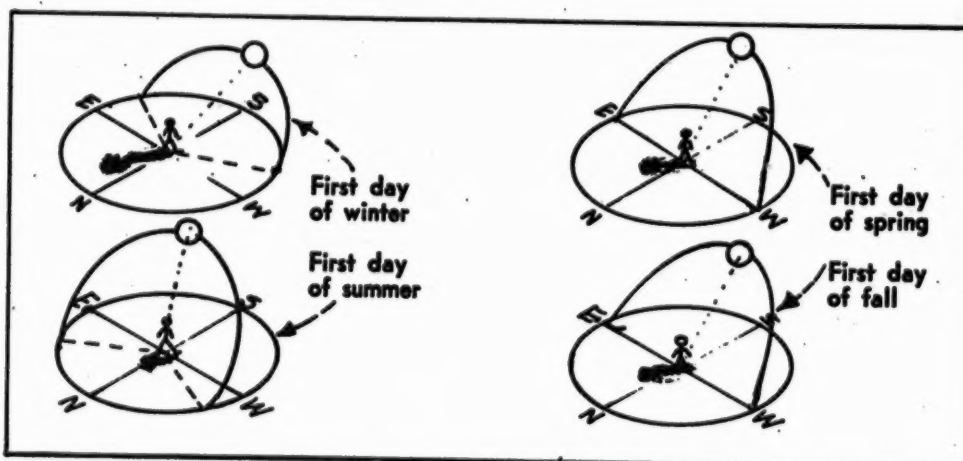
Causes of the seasons.

The sun's rays strike the northern hemisphere almost vertically in our summer, at a slant in our winter.



Tilt makes the difference.

The sun is *seen* high overhead in the sky during our summer, lower in the south in the sky during our winter.



The sun at noon at the beginning of each season.

As the earth rotates on its axis, causing day and night, the northern hemisphere receives more hours of daylight in our summer than it does in our winter. (Notice that the North Pole has continual daylight in our summer and no daylight in our winter.)

In spring and fall (more exactly, at the spring and fall *equinoxes*, about March 21 and September 21) both hemispheres have days and nights of equal length.

All the foregoing relates to the change of seasons in New York. In summer, when the sun is nearly overhead in the sky, its rays strike New York almost vertically; consequently the strength of the sunlight received is great. In addition, there are many hours of day during which sunlight can heat our area. In winter, when the sun is low in the sky, its rays strike

the earth at a slant. Slanted rays do not heat the earth as much as vertical rays for two reasons.

Slanted rays spread out over a large part of the earth's surface. The amount of heat produced at any one spot, therefore, is less than when the rays strike vertically.

Slanted rays travel a greater distance through the earth's atmosphere than do vertical rays. Some of their energy is given off to the atmosphere and less is left to heat the earth.

Combining this decrease in the *strength* of the sunlight received by the earth with a decrease in the *hours* of sunlight, we find the colder conditions which prevail during our winter.

Although December 21st and June 21st (or days close to these) are, respectively, the shortest and longest days of the year in the northern hemisphere, they are not usually the coldest and the hottest days. The earth's temperature changes gradually as the earth gains or loses heat.

In our summer, for example, there is a heat "bank" or accumulation of heat because the days are longer than the nights. The earth does not have enough time to cool off completely; therefore, daytime temperatures remain high. In our winter, with the nights longer than the days, there is an accumulating heat deficit, so the earth cools off.

Approaches and Learnings for the Child

By the fourth grade, children have had many experiences with weather elements on a day-to-day basis. They have learned how to make and how to use some weather instruments. They are now ready to explore the seasonal aspects of weather. The astronomical explanations of seasons (see *Background for the Teacher*, pages 225-226) are too complex for most fourth-grade children, but they can make some seasonal inferences by doing "case studies" of observable conditions during the different seasons.

By observing and recording average daily temperatures, children obtain evidence that average temperatures change from season to season. They infer that one reason for these changes is the variation in the *amount* (hours) of sunlight received. These variations can be determined by observing and recording the time of sunrise and sunset from week to week, month to month, and season to season. The variations in the *strength* of sunlight received can be studied indirectly by observing differences in the length of shadows from week to week, month to month and season to season. Children learn that the length of a shadow is related to the

height of the source of light. (The word "height" applied to an astronomical body does not refer to distance, but rather to *position* in the sky. A body high in the sky is nearly overhead; a body low in the sky would be closer to the horizon.) Because it would be hazardous for children to determine the height of the sun by looking directly at it, they may infer its height by measuring the length of the shadow produced by an object such as a flagpole. They develop the concept that there is a relationship between the length of the shadow, the height of the sun in the sky, and the strength of the sunlight received at a given time and place.

From the activities suggested, children learn the following.

New York has a yearly cycle of four seasons: autumn, winter, spring, and summer.

As the seasons change, there is a change in the temperature.

The number of hours of daylight, and the height of the sun in the sky, also change gradually.

Around June 21st, the sun is in its highest position in our sky and shadows are shortest.

Around December 21st, the sun is in its lowest position in the sky and shadows are longest.

For each season the average temperature is determined chiefly by

a. the number of hours of daylight

b. the angle at which sunlight strikes the earth.

Rays of sunlight which strike the earth directly warm it more than rays which strike it at a slant.

1. What signs of fall (a), winter (b), spring (c), summer (d), can we observe?

Discuss with the children the name and distinguishing characteristics of the season they are presently experiencing. They might mention the clothes they wear, the amount of time they spend outdoors, the changing appearance of trees. Encourage them to relate their personal experiences with the average temperature and amount of daylight during the period. Some children may have observed not only the time of sunrise and sunset, but the position of the sun on the horizon when it rises and sets.

Ask children to predict the changes that will occur as the present season is followed by the next. They will probably know that the weather will get warmer (or colder), and the days longer (or shorter). If they do not mention longer or shorter shadows, lead them to discuss this change.

Plan with the children to make a "case study" of the changes they observe as one season changes to the next. List the questions they want to answer and prepare charts for the classroom and the children's notebooks to record their observations.

Note: Select any one of the three periods (a.), (b.), or (c.) on pages 228 to 238 for your "case study": (a) *Fall to Winter*, page 229 (b.) *Winter to Spring*, page 236. (c.) *Spring to Summer*, page 237. Adapt the experiences given under (a.), *Fall to Winter*, if you select (b.) or (c.) for your study. The *Summer to Fall* season cannot be used for a "case study" because of the summer vacation. It may be feasible, however, to infer what will happen during this season as an extension of the case studies of other seasons, as suggested in (d) *Summer to Fall*, page 237. Individual children may verify these predictions during the summer vacation.

- *Each season has its own signs—changes in plants, animals, amount of daylight, kind of weather.*
- *We can study seasonal changes by keeping records of the time of sunrise and sunset, the temperature, and the length of shadows.*

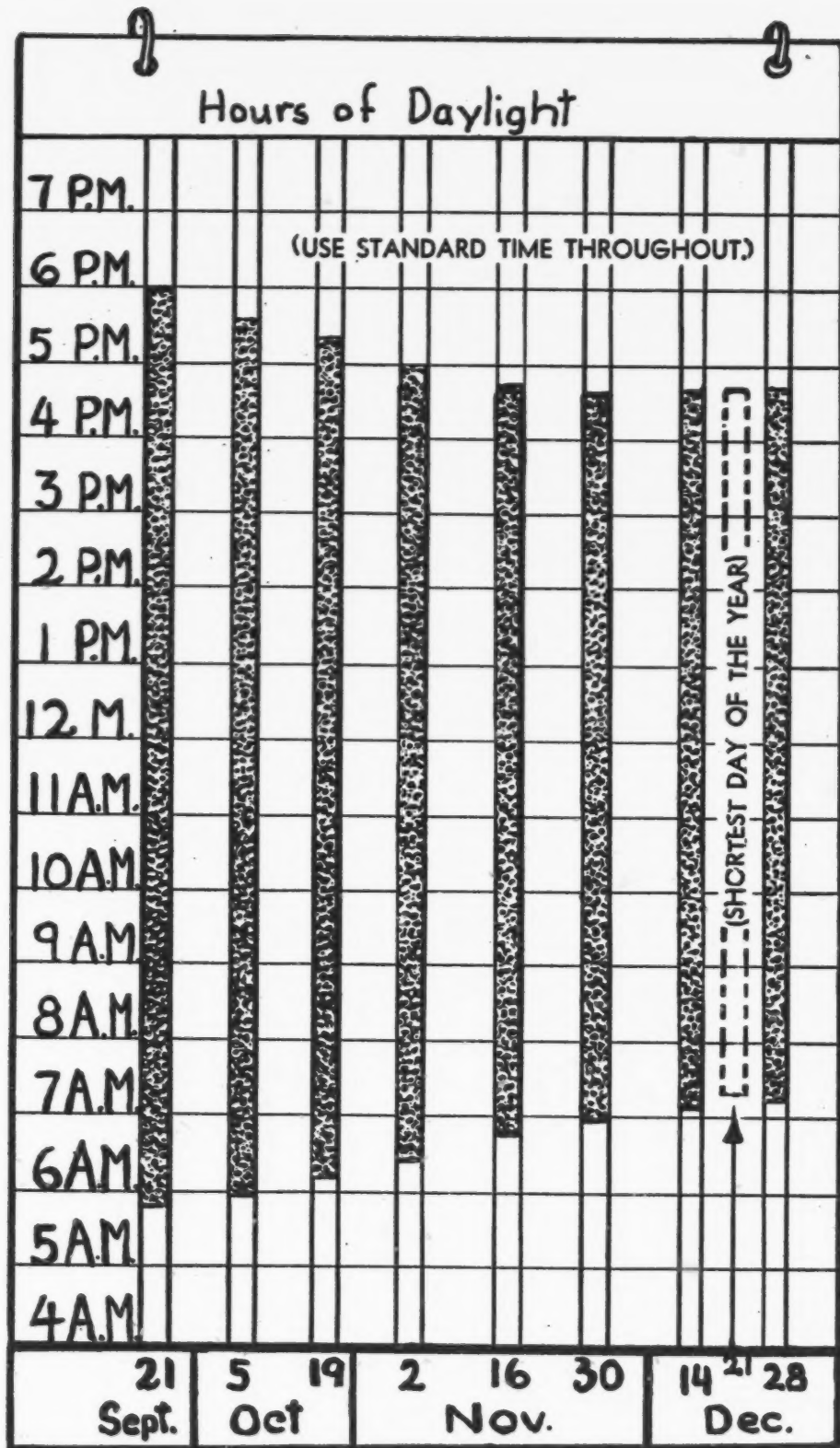
(a.) FALL TO WINTER

2 (a). How long is the sun out during this period?

Beginning on or about September 21 and at regular intervals thereafter, indicate the hours of daylight on a chart such as the one on page 230. Seek help from calendars, newspapers, radio, television, and almanacs. Have the children mark off the dates selected. (Do not enter marks in advance.) Then color in the column between the two marks, to indicate the daylight hours. The interval between recordings may be two weeks or any other time interval desired by the teacher and the class. In this way an original bar graph is made from live data. As the chart develops, inspection of the bars on the graph will reveal to the children that the hours of daylight decrease as we go from fall (autumn) into winter.

Some children may also keep a table as follows, to show the actual time in hours and minutes.

1960	9/21	10/5	10/19	11/2	11/16	11/30	12/14	12/21	12/28
Sunrise	5:46	5:59	6:13	6:28	6:43	6:58	7:10	7:15	7:17
Sunset	6:00	5:38	5:17	4:59	4:47	4:39	4:39	4:42	4:46
Daylight Hours	12:14	11:39	11:04	10:31	10:04	9:41	9:29	9:27	9:29



As fall changes to winter, the days are shorter.

In making the suggested table, fill it out on the days indicated; do not anticipate results. This will allow the children to make discoveries about the hours of daylight from current observations and records.

- *As fall changes to winter, the hours of daylight decrease.*
- *We have the fewest hours of daylight on or about December 21, our shortest day.*

3 (a). How does temperature change during this period?

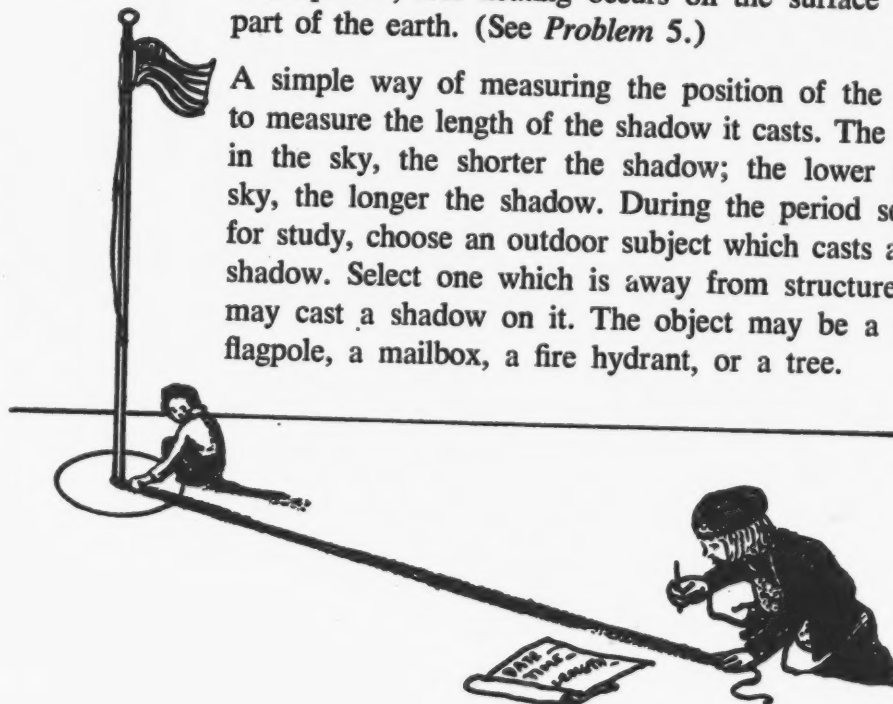
During the same period of time that the children are recording the daylight hours, set up a chart such as the one on page 232 to record and study temperature changes. Select a convenient time at which to observe (at biweekly or other regular intervals) the temperature on an outdoor thermometer in the shade. Observe it at the same hour on each occasion and then record the temperature by coloring a column to the appropriate height. Or record daily average temperature. (See newspapers.)

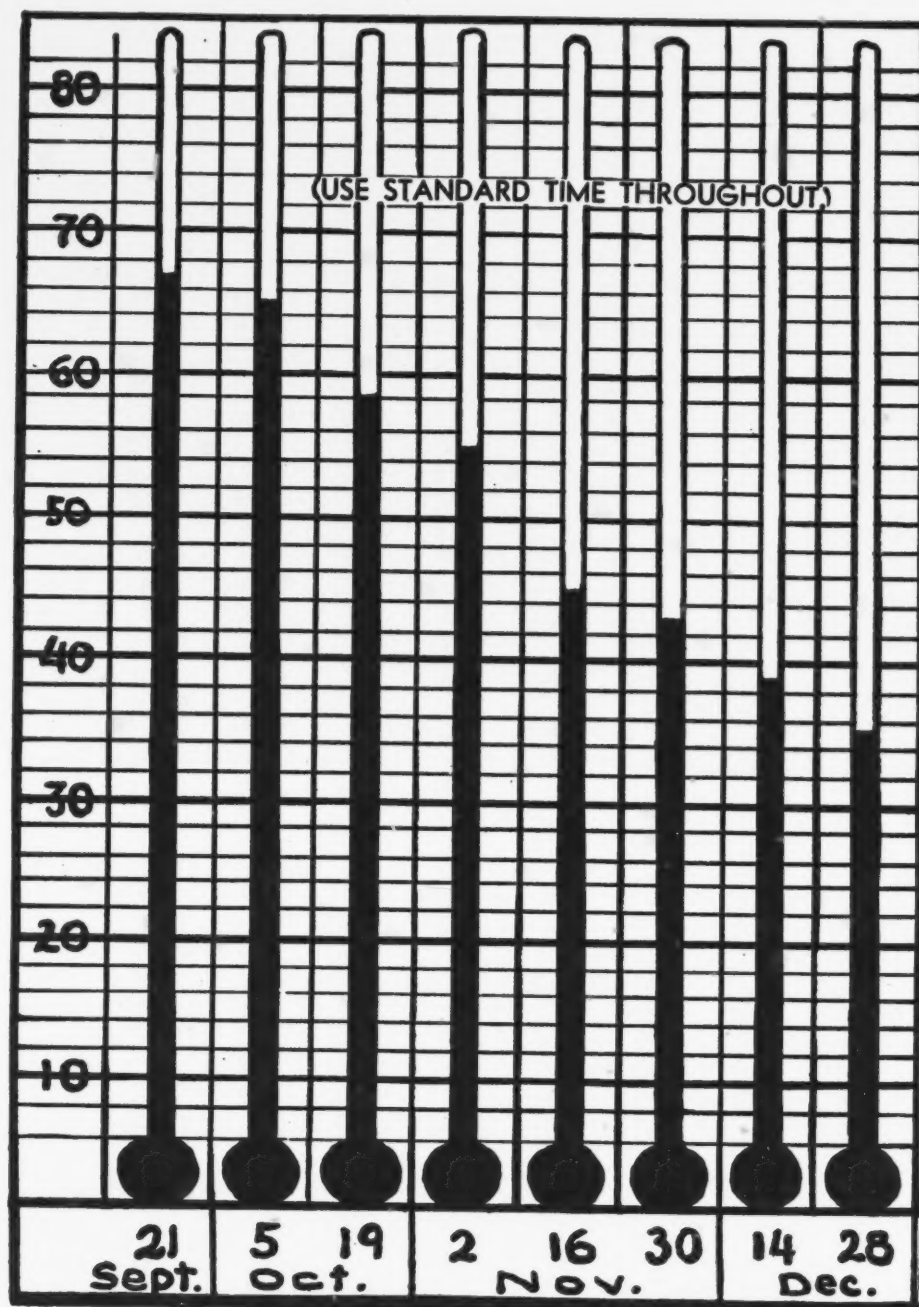
- *As fall changes to winter, the temperature generally drops.*

4 (a). How high is the sun in the sky during this period?

Note: The height of the sun in the sky is a key factor in determining the seasonal variations in temperature. As fall changes to winter, the sun's path across the sky appears to be lower and farther south each day. Its rays strike the earth at more and more of a slant. As a consequence, less heating occurs on the surface of our part of the earth. (See Problem 5.)

A simple way of measuring the position of the sun is to measure the length of the shadow it casts. The higher in the sky, the shorter the shadow; the lower in the sky, the longer the shadow. During the period selected for study, choose an outdoor subject which casts a good shadow. Select one which is away from structures that may cast a shadow on it. The object may be a school flagpole, a mailbox, a fire hydrant, or a tree.

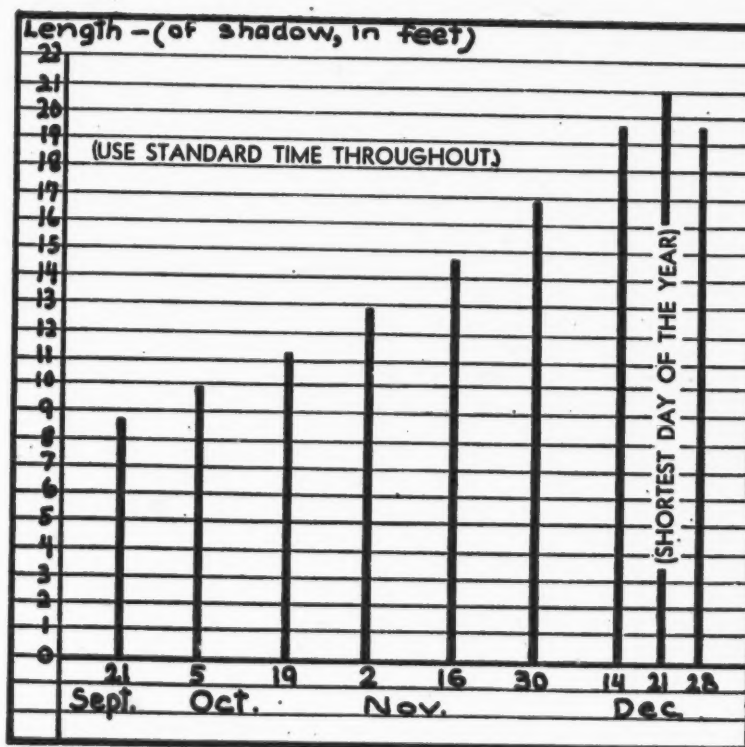




This chart is based on averages; your chart will be different.
On your chart, does the temperature drop as winter comes?
(See Problem 3a, page 231.)

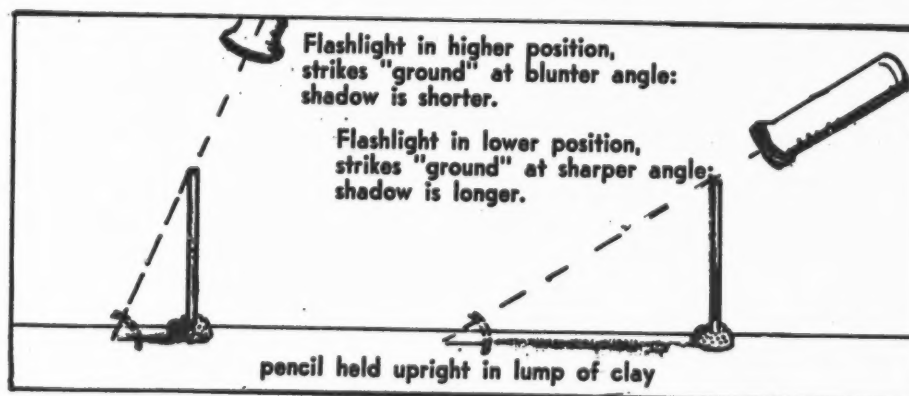
GRADE FOUR

Observe and measure the length of the shadow at the same time of day at biweekly or other regular intervals. Make a chart to record the length of the shadows.



Shadows lengthen as we go from fall into winter.

After readings of shadow lengths have been recorded for several weeks, you may want to demonstrate in the classroom the relationship between the height of the light and the length of a shadow. Provide each group of children with a flashlight and a small object (eraser, lipstick, or package of gum). Darken the room. Encourage the children to hold the light at different angles over the object. They might record the length of



The lower the light, the longer the shadow.

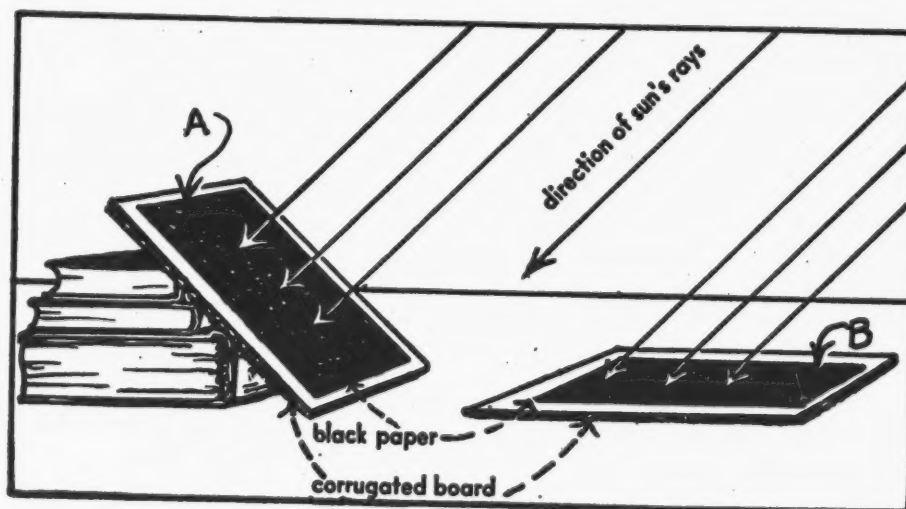
shadows by markings on a piece of paper under the shadow or by tearing strips of paper the length of the shadow.

- *When the light is high and directly over an object, the shadow is short.*
- *When the light is low and at a slant, the shadow is long.*
- *As fall changes to winter, shadows lengthen.*
- *As fall changes to winter, the sun appears lower and lower in the sky.*
- *As fall changes to winter, the sun's rays hit the earth at more of a slant.*

5 (a). What happens as the slant of the sun's rays changes?

From their experiences with the changes in the length of shadows in *Problem 3*, children learned that the position of the sun in the sky at noon varies and that, as a result, the sun's rays sometimes strike the earth vertically and sometimes at a slant. Through discussion, lead them to understand that the rays are nearly vertical at noon in the warmer weather and more slanted in the colder weather.

To enable the children to see the effect the slant of the sun's rays has on the strength of the heat received, an experiment can be set up in the classroom. Use two pieces of black paper, (black absorbs heat rays better than lighter shades) each about 4 inches square, to represent the earth's surface. On a sunny day, place each in sunlight (indoors) as follows. One receives the sun's rays fully: at a 90° angle; the other is half-turned away: at a 45° angle to the sun's rays. Mount each, preferably on corrugated board because of its insulating qualities.

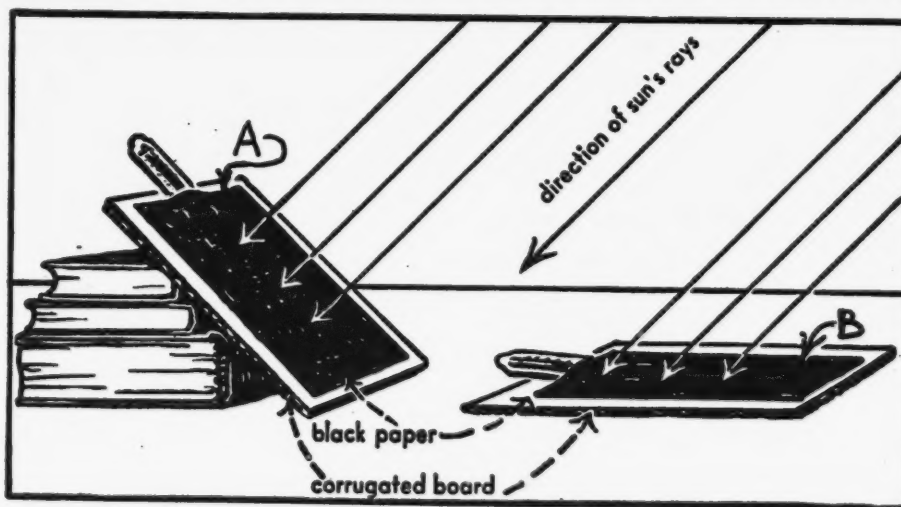


The paper in direct sunlight feels warmer.

GRADE FOUR

Children should feel and compare both pieces of black paper after 2,4,6,8, and 10 minutes, and report their findings.

To measure the effect of slant more accurately, attach two thermometers to the cardboard and cover with black paper. Again the paper is placed so that it faces the sun's rays at different angles. Read the thermometers after the same intervals as before and make a record of the observations.



The thermometers show that we are right.

Discuss the observations made in the previous problem with respect to the increasing slant of the sun's rays as winter approaches. Children may infer that less heat is received when the slant is greater.

- *Slanting rays of the sun produce less heat at a particular spot than direct rays.*
- *Since the slant in our part of the earth increases each day in the fall, the earth receives less heat and cools off.*

6 (a). What is the general weather picture during this period?

Building on the measurement experiences which children had in Grade 3, make a study of the amount of rainfall and snowfall, and the strength of winds during the time under study. Children suggest ways to keep records and make charts of these weather elements.

Review the two factors responsible for the drop in temperature.

The sun heats the earth for shorter periods of time (see *Problem 2*).

The sun's slanting rays produce less heat on a particular spot on earth (see *Problem 4 and 5*).

- *As fall changes to winter, the average temperature drops slowly.*

- *Slanting rays heat a surface less than direct rays.*
- *As the sun heats the earth for shorter and shorter periods, and as the rays of sunlight slant more and more, the earth becomes cooler and cooler.*

(b.) WINTER TO SPRING

Choose an appropriate time span, such as January 1st to March 31st, to observe changes from winter to spring.

2 (b). How long is the sun out during this period?

Adapt to this period the fall-to-winter experiences on pages 229 to 231.

- *As winter changes to spring, the hours of daylight increase.*
- *About March 21, night and day are equal.*

3 (b). How does the temperature change during this period?

Adapt for this period the experiences under fall-to-winter, on page 231.

- *As winter changes to spring, the temperature generally rises.*

4 (b). How high is the sun in the sky during this period?

Adapt to this period the fall-to-winter experiences on pages 231 to 234.

- *As winter changes to spring, shadows become shorter.*
- *As winter changes to spring, the sun appears higher and higher in the sky.*
- *As winter changes to spring, the sun's rays hit the earth more directly.*

5 (b). What happens as the slant of the sun's rays changes?

Adapt to this period the fall-to-winter experiences on pages 234 to 235.

- *Direct rays of the sun produce more heat at a particular spot than slanting rays.*
- *The earth warms up as the rays become more and more direct.*

6 (b). What is the general weather picture during this period?

Adapt to this period the fall-to-winter experiences on pages 235 to 236.

- *As winter changes to spring, the average temperature rises slowly.*
- *As the sun heats the earth for longer and longer periods, and as the rays of the sunlight become more and more direct, the earth becomes warmer and warmer.*

(c.) SPRING TO SUMMER

Choose an appropriate time span, such as March 22nd to June 21st, to observe changes from spring to summer.

2 (c). How long is the sun out during this period?

Adapt to this period the experiences under *fall-to-winter* on pages 229 to 230.

- *As spring changes to summer, the hours of daylight increase.*
- *The longest day of the year occurs about June 21.*

3 (c). How does the temperature change during this period?

Adapt to this period the experiences under *fall-to-winter* on page 231.

- *As spring changes to summer, the temperature generally rises.*

4 (c). How high is the sun in the sky during this period?

Adapt to this period the *fall-to-winter* experiences on pages 231 to 234.

- *As spring changes to summer, the sun appears higher and higher in the sky.*

5 (c). What happens as the slant of the sun's rays changes?

Adapt to this period the *fall-to-winter* experiences on pages 234 to 235.

- *Direct rays of the sun produce more heat at a particular spot than do slanting rays.*
- *The earth warms up as the rays become more and more direct.*

6 (c). What is the general weather picture during this period?

Adapt to this period the *fall-to-winter* experiences on pages 235-6.

- *As spring changes to summer, the average temperature rises slowly.*
- *As the sun heats the earth for longer and longer periods, and as the rays of the sunlight become more and more direct, the earth becomes warmer and warmer.*

(d.) SUMMER TO FALL

1 (d). What seasonal changes take place from summer to fall?

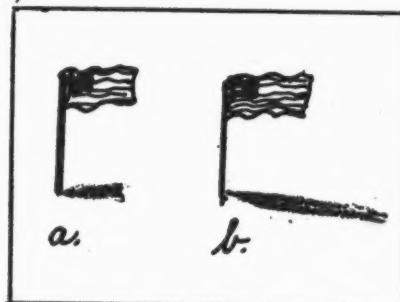
Discuss with the children the general weather picture they might expect for the summer season.

Based on their previous "case studies" of the other seasons, ask the children what seasonal changes would occur from summer to fall. Some of their predictions can be verified by consulting an almanac. Prepare graphs of hours of daylight and average temperatures using data found in the almanac. Compare these graphs with the children's predictions. Individual children may wish to make direct observations during the summer vacation period.

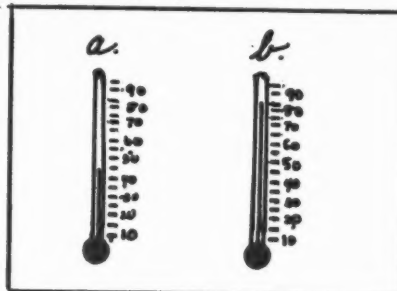
- *As summer changes to fall, the hours of daylight decrease.*
- *As summer changes to fall, the temperature gradually increases and then decreases.*
- *As summer changes to fall, shadows become longer.*
- *As summer changes to fall, the sun appears lower and lower in the sky.*
- *As summer changes to fall, the sun's rays hit the earth at more of a slant.*

EVALUATIVE ACTIVITIES

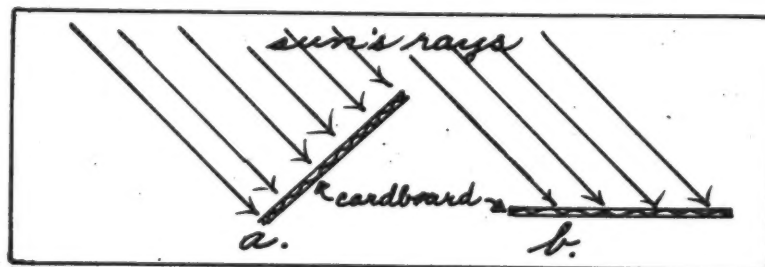
1. Which of the following could be the number of daylight hours in September?
(B.) In December? (A.)
 - A. $9\frac{1}{2}$ hours
 - B. 12 hours
2. Which of the following illustrations could be a 12 o'clock shadow in September?
(A.) In December? (B.)



3. Which of the following illustrations would probably indicate a temperature in September? (B.) In December? (A.)



4. In the change from fall to winter, what happens to
 - a. the number of hours of daylight? (Decreases.)
 - b. to the temperature? (Goes down.)
 - c. to the length of shadows? (Gets longer.) Why? (The sun is lower in the sky.)
 - d. the slant of the sun's rays? (The slant increases.)
5. a. Which of the two pieces of cardboard, in the following illustration, will be warmer after ten minutes in the sun? (A.) Why? (It gets the sun's rays directly; the other cardboard gets the rays on a slant.) How could you prove you were right? (Do an experiment; feel the cardboards; put a thermometer inside or behind each cardboard.)



B. VARIETIES OF WEATHER IN NEW YORK CITY

Background for the Teacher

The "unusual" weather in the New York City region is due in large part to the kind of air masses that sweep this geographic area. Air masses are basically of two types. One air mass may drive in from the tropics, bringing warm air. Another air mass may have originated in ice-covered polar regions, bearing cold air. Air masses retain their identity and most of their characteristics even when they move far from their initial sources. Only gradually are these masses modified by the conditions they encounter. Where air masses meet, a kind of war takes place with one mass pushing against the other. The "battle line" between two air masses is called a *front*.

When the colder air mass advances on the warm air mass, we have a *cold front*. The heavier cold air mass pushes under the warm one like a wedge.

When warm air advances over a retreating wedge of colder air, we have a *warm front*. Moisture in the air condenses, resulting in cloud formation and then in a long, steady rain.

If warm moisture-laden air from the tropics is elevated to higher, cooler levels, violent precipitation may result as the water vapor condenses to form towering thunderheads. A *thunderstorm* may also be caused by the local heating of the ground and the consequent heating of the moist air above the ground. Thunderclouds are formed as the air rises, is cooled, and water vapor in it is precipitated.

Typically, the wind flow over New York is from the west to the east. Consequently, we receive an air mass which has been modified by conditions over continental United States. If this air has lost its moisture and is cool and dry, we enjoy a refreshing cool spell, even in the middle of the summer. On the other hand, a warm air mass from the tropics may beat back a cold mass all the way into Canada and give us in New York a spring-like day in the middle of the winter.

Our area, of course, is subject to the effects of the Atlantic Ocean, so that if the wind blows in from the east, northeast, or southeast, we may get precipitation from the moisture-laden winds of the sea. This precipitation may take the form of fog, snow rain or sleet.

A *hurricane* (a typical tropical cyclone) may originate in the Caribbean region, and initially move north and west because of the natural inclination of the trade winds. As the hurricane moves toward the temperate zone, however, the wind flow generally pushes it into a north and east direction. Hurricanes may, therefore, sweep across a number of areas along the eastern seaboard, including New York.

Another unusual kind of weather is the *ice storm*. This occurs when the following contrasting temperatures prevail: a few hundred feet up, the temperature of the air is above 32°F. and water vapor in it precipitates into rain; at the same time, however, the ground temperature is 32°F. or below. Under these conditions as raindrops fall onto a tree or the ground, the drops of water freeze into ice.

Fog is developed when moisture-laden (warm) air comes in contact with the surface of the earth when it is rapidly cooling. One kind, known as *ground fog*, occurs at night as the ground cools off quickly. The air is chilled and the moisture in it condenses to tiny droplets of water, too small to be pulled down to earth by gravity. When the sun warms the air, the droplets evaporate and the fog disappears. A fog may be regarded as a cloud on the ground.

Weather almanacs, the United States Weather Bureau, and other references testify to the wide variety of weather changes in our city. The following data helps give us some concept of the different records made by weather in this area over the years.

<i>Condition</i>	<i>Measurement</i>	<i>Date or Time</i>
Lowest temperature	—14.3°F	Feb. 9, 1934
Highest temperature	106°F	July 9, 1936
Highest Wind	133 miles per hr. from the southeast	Oct. 15, 1954
Highest snowfall	25.8 inches	Dec. 26-27, 1947
Driest month	.02 inches	June 1949
Wettest month	14.51 inches	Sept. 1882

Approaches and Learnings for the Child

New York City is subject to a great deal of "unusual" weather. We experience many extremes since on any given day there may be extreme divergence from the "average." Such dramatic occurrences as windstorms, thunderstorms, droughts, wet spells, fogs, ice storms, blizzards, and hurricanes are part of our weather picture. During any year, so many of these exceptional weather phenomena occur that it is perhaps true to say that in New York City the "unusual" is usual.

A unit on unusual weather in New York City may be initiated at the outset of the school year. The teacher may utilize children's previous experiences and the aids listed in this handbook such as books, films, and filmstrips. The unit will serve to prepare children to make keener observations when the manifestations of unusual weather do occur: to measure, to keep logs, to make charts, and as a result to deepen concepts. They will also learn that their logs and charts are a kind of first hand "almanac" which may be compared with commercial almanacs and weather reports. Newspaper, television, and radio reports of unusual weather, all help to develop the concept that the New York City area is subject to wide variations of heat, cold, precipitation, and drought.

These weather *extremes* serve as a basis for understanding the "average" weather. Thus, children will discover as they consult almanacs that April is no more rainy than most of the other months. Actually, July and August are the rainiest months, on the average. A unique feature about New York is the extent to which any day, week, or month may depart violently from the average. This is in distinct contrast to the weather pictures in places like Hawaii, where the constant trade winds and the moderating influence of the warm Pacific Ocean help to maintain each day, week, and month close to the long-time average.

From the activities suggested, children learn the following.

In any year it is usual to have a great deal of "unusual" weather in New York City.

Lightning is a giant electric spark.

Thunderstorms generally occur in the summer.

Hail sometimes accompanies thunderstorms.

Ice storms are caused by rain which freezes on objects on or near the ground.

A fog is a cloud on the ground.

Hurricanes are tropical storms with very strong winds.

A blizzard is a heavy snowstorm with high winds and very low temperatures.

A rainbow may occur after a rain.

Haze is caused by dust in the air.

Cold waves, heat waves, and drought are part of the New York City weather.

1. What "unusual" kinds of weather do we have in New York City?

Ask the children to recall the unusual kinds of weather they have observed and experienced. Have them bring in photographs, or pictures clipped from magazines and newspapers, illustrating unusual weather. Use a film to illustrate the characteristics of extreme weather such as thunderstorms and blizzards. Finally, encourage the class to list signs or evidence of unusual kinds of weather. Children may come up with a list such as the one on page 243.

A chart such as this one may be also developed as a result of individual or committee reports which children present to the class. The teacher will guide groups and individual children to use source materials: books, almanacs, weather reports in the newspapers, radio, television, and the telephone weather service, WE 6-1212.

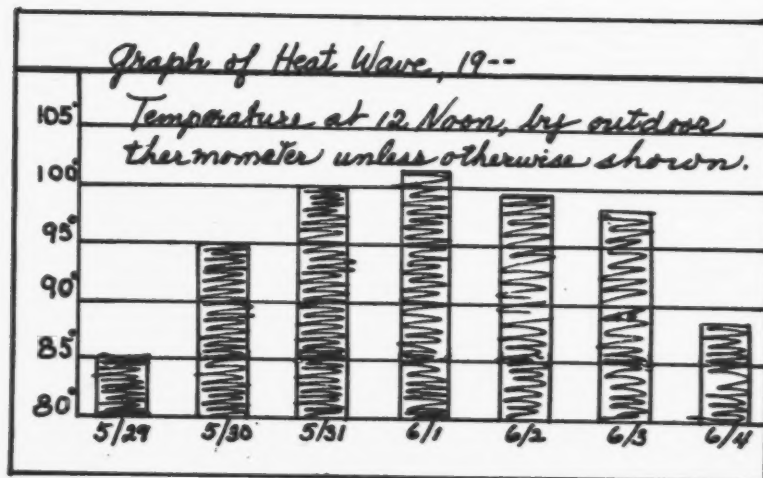
When unusual weather does arrive, a weather log should be maintained to indicate the time it occurs. Specific measurements may be charted or pictured in a bar graph. Some kinds of weather may be experienced or observed from indoors. When conditions are hazardous, use information from newspapers, radio and television.

GRADE FOUR

UNUSUAL WEATHER	SIGNS OR DESCRIPTIONS
Thunderstorm	Heavy rain, lightning, thunder, strong winds, on a warm day that had been sunny
Hurricane	Very strong winds, heavy rains, high waves, usually in months August to October
Blizzard	Heavy snow, high winds, low temperatures
Ice Storm	Cold rain or drizzle, water turns to ice on street buildings, trees
Fog	Air moist and cloudy, difficult to see objects clearly down the street
Haze	Low visibility, calm or very light wind
Rainbow	Band of color in the sky when sun comes out after a shower
Cold Wave	Very low temperatures over a long period
Heat Wave	Very high temperatures over a long period
Drought	Very little rainfall over a long period

The following log and chart exemplify the use of direct observation and measurement, and the utilization of Weather Bureau reports.

LOG OF HURRICANE — 1965			
<i>Date</i>	<i>Time</i>	<i>Measurements</i>	<i>Source of Comments</i>
Oct. 3, 1965	7 A.M.	Wind Speed: 50 MPH	T.V. Report
Oct. 5, 1965	9 A.M.	Wind Speed: 60 MPH	Radio Report
Oct. 8, 1965	1 P.M.	Wind Speed: 90 MPH Rainfall: 2½ inches	T.V. Report T.V. Report
Oct. 12, 1965	6 P.M.	Wind Speed: 80 MPH	Newspaper Report



- In any year it is usual to have a great deal of "unusual" weather.
- Each kind of unusual weather has its own distinct features.

2. What happens during a thunderstorm?

During a thunderstorm ask children to describe what is happening, or, have children recall thunderstorms they have experienced. Their observations will include the sound of thunder, darkening of the sky, torrent of rain, flash of lightning, and high winds.

What is lightning? What is thunder? After children express their ideas, the teacher should suggest that they can make a kind of "lightning"



Miniature lightning.

on a small scale. This demonstration works best on a dry day. Have children run their combs through their hair. What do they *hear*? (Crackling sounds; these are caused by tiny electric sparks.) Have children rub their shoes against a rug, then almost touch other children's hands or a metal object. What happens? (They *feel* a shock; these are caused by tiny electric sparks.)

Miniature lightning may also be *seen* in the following manner. Rub an inflated balloon with a piece of nylon, wool, or fur. In a darkened room, bring your finger near the balloon. Is there a small flash and a crackle of the miniature "lightning bolt"?

Note: There is a relationship between the rubbing of the comb through the hair and the natural phenomenon of lightning. Within a storm cloud, the general movement of the air and the turbulent motions of updrafts and downdrafts cause water droplets to be torn apart by friction with the air. As a result, the droplets become electrified. Eventually the thundercloud builds up enough electricity to cause a discharge. The discharge may take place within the cloud, between one cloud and another, or between the cloud and the earth. Lightning, leaping through the air, heats it and causes it to expand suddenly. This movement starts a tremendous sound wave, which reaches our ears as thunder.

- *Lightning is a giant electric spark.*
- *Thunder is the sound made when lightning heats the air and makes it expand suddenly. This starts a wave in the air which reaches our ears as thunder.*

3. What safety rules should we follow during thunderstorms?

Lightning discharges are attracted to the tallest objects in an area. That is the reason lightning strikes the Empire State Building in New York City many times during one summer storm. Lightning rods are placed on buildings to ground the electricity and thus to prevent damage.

Have children discuss the safety rules they should follow during thunderstorms.

Keep away from tall trees, particularly isolated trees.

Keep off lakes and beaches.

Keep away from iron railings.

If possible, go indoors.

- *Thunderstorms generally occur in the summer.*
- *Lightning is carried more easily by objects when they are wet.*

- *Lightning is carried (conducted) easily by metals.*
- *Lightning is attracted to high buildings, flagpoles, trees, and other tall structures.*

4. Why do we see lightning before we hear thunder?

See Problem 9, page 215.

- *Thunder is the sound caused by the expansion of air which was suddenly heated by lightning.*
- *Light travels faster than sound.*

5. How is hail formed?

Find pictures showing hailstones. Discuss these. What are they? How are they formed? During what season have the children generally experienced hail?

Note: Hail, which sometimes occurs during a thunderstorm, can be produced only if there are strong currents of rising air. Hail begins as falling rain, but when a rising air current carries the drops up where it is cold, the drops freeze into ice. The ice-pellets may fall and be carried up again several times. Each time they fall, water vapor condenses on them; each time they rise, the water freezes into another layer of ice. When the resulting hailstones are too heavy to be lifted any more by the rising air current, they finally fall to earth. The largest hailstone ever recorded in this country weighed 1½ pounds. Because of the way in which they are formed, hailstones consist of a number of concentric layers that can be distinguished easily if the stones are cut in two.

Hail should not be confused with sleet, which is rain that freezes as it falls to the earth.

- *Hail sometimes accompanies thunderstorms.*
- *Hail is made when raindrops are carried aloft to freezing temperatures.*

6. What is an ice storm?

After an ice storm, observe the ice which is on trees and shrubs and telephone wires, making them look beautiful, but in some cases damaging them because of its weight. If no ice storm occurs, ask children if they recall this phenomenon, and have them describe it.

Children may wish to reproduce the result of an ice storm. Have them dip a dry twig in cold water. Place it in a refrigerator freezer until the

water freezes. Repeat this on the same twig, at 15 minute intervals, many times, until about $\frac{1}{8}$ to 4-inch of ice coating appears on the twig. Give each child an opportunity to examine the ice.

Children should also keep records of the outdoor temperatures during the winter to determine on which days an ice storm might occur if a warm layer of moist air moves over the city (those days when temperature goes below 32°).

- *Ice storms are caused by rain which freezes on objects on the ground.*

7. Why do we have fog?

On a cold day children can "see their breath" outdoors. This is a miniature fog, caused by the condensation into tiny droplets of the water vapor in the air they exhale.

Have children make a miniature fog by blowing on a pane of glass or mirror which has been chilled. They will notice the condensation which forms. This condensation is similar to the tiny droplets of water which form clouds and remain suspended in air. Children will be interested in knowing that fog is a cloud on the ground. Have them relate experiences of impaired visibility and tell how objects outdoors feel during a fog.

Note: Children should be guided to understand the following. Because we are near the warm moist air which accompanies the Gulf Stream, New York City is subject to fogs which are sometimes so dense that transportation facilities are disrupted. Clouds consist of millions of very tiny droplets of water. When water evaporates, individual water molecules move into the air. In this form the water is called *water vapor*. As has been previously learned, when air containing invisible water vapor cools, in this case by rising in the atmosphere, the water vapor condenses and forms little droplets. These tiny droplets, which make up a cloud, usually form around very small particles of dust, pollen, smoke, ash, or salt. The individual drops of water in a cloud are very small. It takes almost a million of them to make one rain-drop. These droplets are kept up in the air by rising currents which lift them faster than they can fall. Sometimes water vapor in the air near the surface of the earth is cooled and condensed to drops of water. The result is a *cloud* on or near the ground or, as we know it, a *fog*. It is, therefore, possible to have one's head "in the clouds."

Conditions of humidity and wind must be just right for a fog to form. Too much wind may blow the fog away, or the fog may dissipate as the sun rises during the day and heats the air.

- *A fog is a cloud on the ground.*
- *Cities such as New York, San Francisco and London, which are near warm bodies of water, may sometimes experience dense fogs.*
- *Wind and humidity affect the formation of fog.*

8. What happens during a hurricane?

It is unlikely that during any one year New York City will experience the full force of a hurricane. However, children have heard of hurricanes and may even have experienced one during their lifetimes.

Note: A hurricane usually begins as a tropical storm over water during the hurricane season (June through November). As it moves over the water it builds up and the winds which circle around its "eye," or center, become stronger. When the winds reach 75 mph or stronger, the storm is technically called a hurricane.

A hurricane has two important motions. The first is the motion of the winds which circles the eye in a counterclockwise action. These winds increase in velocity nearer to the eye. However, the eye of the storm is calm. The second motion is the forward motion of the entire storm which is mapped by weathermen as they follow the movement of the eye of the storm. Warnings are given to coastal areas of the United States as the storm approaches. Because the hurricane may be a few hundred miles in diameter, widespread damage from wind and flooding accompany the storm as it moves inland near populated areas. Most property damage done by hurricanes is the result of *flooding*.

There is a general path of hurricanes which begin in the eastern Caribbean and move westward toward Florida. Often they change direction



After the hurricane.

and move northward along the eastern coast of the United States and then will move inland or out to sea, depending upon the general weather picture during that period. Hurricanes usually lose strength as they move inland or across mountain ranges.

Children may be asked to do research on hurricanes in almanacs, magazines, and encyclopedias, to answer the following questions.

Where do they start?

How do they move?

During what time of the year do they usually form?

How are they named?

How fast are the winds?

How fast is their forward motion?

What kinds of damage do they cause?

How does the warning system help us?

How is radar used to track a hurricane?

How do weather satellites keep check on hurricanes?

How many hurricanes have struck New York City?

- *Hurricanes are tropical storms with strong winds.*
- *Hurricanes sometimes strike New York City.*
- *Most property damage done by hurricanes is due to flooding.*

9. What is a blizzard?

A blizzard is a heavy snowstorm accompanied by high winds and very cold temperatures. The usual type of snowfall in New York City cannot be termed a blizzard, but blizzards do come to our city.

Children may do research on blizzards in New York City, to answer the following questions.

What is a blizzard?

What happens to transportation and communications during and after a blizzard?

When did big blizzards strike New York City?

What were the wind speeds during blizzards?

How deep was the snow left by blizzards?

- *A blizzard is a heavy snowstorm with high winds and very cold temperatures.*
- *During some winters there are blizzards in New York City.*

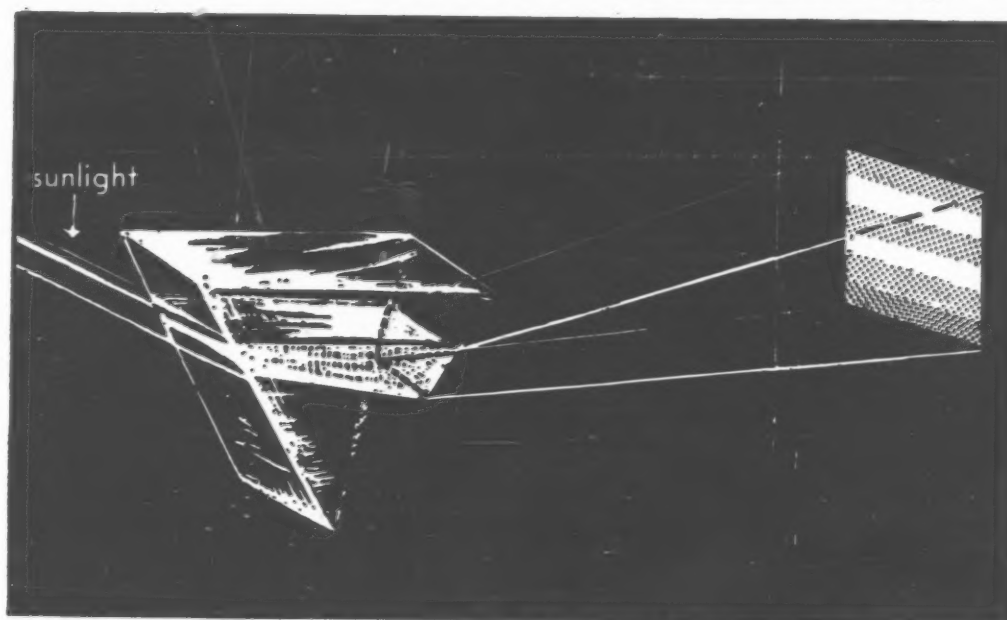
10. What causes a rainbow in the sky?

During a mild, sunny day, take the class outdoors to the lawn or playground. Ask the custodian to connect a garden hose to an outlet. Adjust the nozzle so that the finest spray is obtained. Have the class look at the spray when the sun is *behind* them. This works best when the sun is not too high overhead.

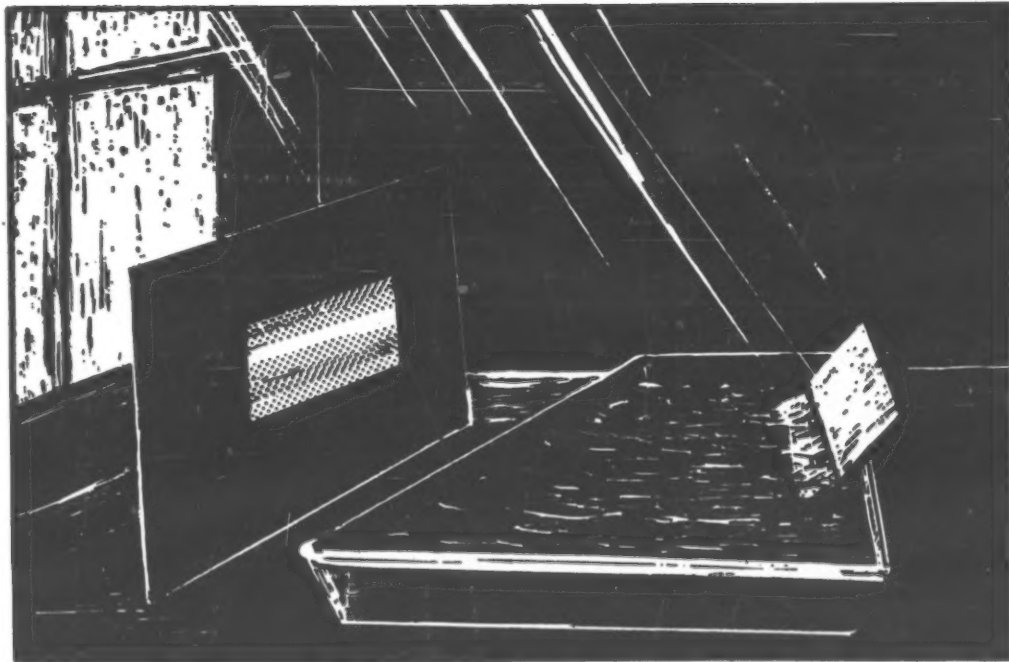
Ask the class which colors are visible, which are on top, and which below. Show how the rainbow disappears when the spray nozzle is pointed toward the sun. See what happens when the spray is made coarse. Point out the similarity between the small rainbow they have made and the huge arc formed in the sky after a rain. (A rainbow may also be seen before a rain when conditions are favorable.)

Help children to understand that the rainbow which appears after a rain is formed in a similar way to that formed by the spray of a garden hose. Ask them to be especially observant the next time they see a rainbow. What colors do they see? In what order are the colors? Is the sun behind them as they look at the rainbow?

Hold a glass prism in a shaft of sunlight near a window. Rotate the prism so that a multicolored beam is thrown somewhere on the ceiling or wall. Ask the children to study the order of appearance of the colors. They should note that the arrangement of colors is: red, orange, yellow, green, blue, violet. Explain that these colors were originally part of the white sunlight. When the beam of sunlight goes through the prism, it is bent. Because the different colors in the sunlight are



A prism makes a "rainbow".



Another way to make a "rainbow".

bent at different angles, the prism spreads them out to form a spectrum (a band of rainbow colors).

An alternate method for obtaining rainbow colors is to place a mirror in a pan of water. The class will observe that the rainbow colors produced in this way are in the same order as those caused by a prism.

Children may also experiment with cut-glass bowls, beveled mirrors, glass beads which have facets, fish tanks, and other clear glass objects, in order to get rainbow colors from sunlight.

Children should understand that the drops of water in the air which produce a rainbow act as prisms: they separate sunlight into its component colors.

- *After a rain there are tiny drops of water left in the air.*
- *These drops break up sunlight into the rainbow colors.*
- *The sun must be behind the observer for him to see a rainbow.*

11. How clean is our air?

The problem of air pollution in New York City is a serious one. Health officials are concerned about air pollution. Sometimes the amount of pollution is high and sometimes it is low, depending upon the weather. Each day, approximately the same amount of impurities goes into the air from smokestacks, vehicle exhausts, and other sources. This pollu-

tion by solid and gaseous particles will remain in the air if there is no wind to blow it away, or if there is a layer of warm air above the city acting as a blanket.

The phenomenon known to the weatherman as haze gives visible proof that much dust can remain suspended in the air. During haze, visibility is reduced because of suspended particles in the air.

Have children place an open coffee can lined with a disc of white paper outside the window of the classroom or on a roof for a period of a few weeks. Remove the paper and examine it with a magnifier. Ask children where they think the dust and debris come from.

Have children examine window sills, drapes and other materials subject to coatings of dust from the outside air.

Children should record hazy days on their weather calendars and keep a record of the air pollution index for a period of several weeks. This index is an arbitrary computation based on the amount of sulphur dioxide, carbon monoxide, and smoke in the air as recorded by the city Air Pollution Control Laboratory. The average daily index is 12 and the emergency level is placed at 50. For example, the following in a record of air pollution from February 24—March 2, 1966.

Feb. 24	16.1	Feb. 28	15.8
Feb. 25	10.8	March 1	13.1
Feb. 26	9.1	March 2	6.6
Feb. 27	8.3		

On their record each day, have children add other observations such as smarting of eyes and coughing.

- *Haze is a weather phenomenon caused by dust in the air.*
- *The air around New York City contains much dust from chimneys, smokestacks, vehicle's exhausts, and other sources.*
- *When the air contains too much dust or certain chemicals we say it is polluted.*

12. What happens in a heat wave, cold wave, and drought?

a. During the warmer months of the year, children will be on the lookout for a heat wave. How high will the temperature go? How long will the wave last? How does the heat wave affect people, industry, various kinds of businesses? Chart the temperature on a bar graph.

- *New York City has heat waves during the summer months.*

GRADE FOUR

b. During the winter months we sometimes have a prolonged period of unusually cold weather. How low does the temperature fall? How do these readings compare with readings of previous years? Is the cold wave limited to New York City or is it widespread? How strong are the winds? Where do the winds come from? When this kind of weather develops suggest that the class chart the temperatures on a bar graph.

- *New York City has cold waves in winter, with very low temperatures.*
- *Cold waves come to New York City from Canada and the Arctic.*

c. Discuss the measures that New Yorkers were asked to take with respect to water conservation. Why were we asked to eliminate lawn sprinkling, washing of automobiles, unnecessary running of water?

What is the appearance of lawns and parks during a drought? What can children do to help out in the water emergency?

Consult almanacs to determine the average monthly rainfall in the New York City area. What is the average yearly rainfall? (Appr. 40").

- *Our rainfall average is about the same each month of the year (3½") with the exception of July and August (4½").*
- *There are no "typically" dry months in New York City.*

EVALUATIVE ACTIVITIES

Give reasons for the following.

1. We should not stand under a tree during a thunderstorm. (Lightning usually strikes the tallest objects.)
2. We see lightning before we hear the thunder that goes with it. (Light travels faster than sound.)
3. Hail is made when there is a strong updraft in a thundercloud. (Water drops are raised to a place where there is a freezing temperature.)
4. Hailstones sometimes have a number of rings around them. (Each ring is a layer of ice formed at one of the times the stone is lifted up.)
5. Ice sometimes forms on trees. (Rain freezes on the cold tree.)
6. We sometimes can "see" our breath. (Water vapor in the air we breathe out condenses into tiny drops on cold days.)
7. Rainbows come after a shower. (Sun shines on water droplets in the air; each droplet acts like a prism to break light into a spectrum of colors.)
8. Fog sometimes forms over New York City. (Warm, moist air from the ocean is chilled; condensation into water droplets occurs.)

BASIC SUPPLY LIST
FOR WEATHER AND CLIMATE FROM SEASON TO SEASON

*Indicates quantity for entire class; other quantities
specified are for each group of 4 children.

E-1: Science Supply List

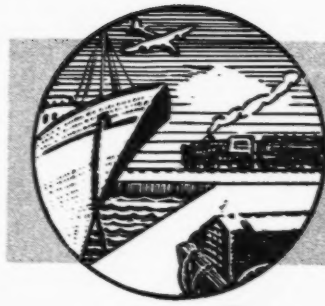
- | | |
|------------------------|----------------------|
| 2 outdoor Thermometers | *1 pkg. Weather Maps |
| 1 Flashlight | *1 Geographic Globe |
| 4 Balloons | *1 Planetarium |
| 2 Magnifying Glasses | *2 Hand Mirrors |
| *2 Prisms | |

G-1: General Supply List

- | | |
|---|--|
| *4 large sheets of Oaktag | 2 sheets of small, black
Construction Paper |
| *1 ball of String
(warp, thread white) | *1 pkg. Graph Paper |
| *2 chalkboard Erasers | *2 plastic Tumblers |
| 5 sheets of Composition Paper | *1 Yardstick |
| 4 Pencils | *2 Rulers, 12" |

Miscellaneous:

- | | |
|----------------------------|--|
| *1 pkg. Plasticene | *1 Garden Hose with nozzle |
| *4 pieces Corrugated Paper | *2 Coffee Cans |
| 4 Combs | *Assorted Fabric Remnants
(Nylon, wool, silk, cotton) |
| *1 piece of Fur | |
| 1 dead Twig | |



Moving Things More Easily

A. MACHINES WITH WHEELS HELP MOVE THINGS MORE EASILY

Background for the Teacher

In common usage, the word *machine* usually refers to machinery such as is found in a factory. An automobile is often called a machine. Early airplanes were called flying machines. All machines, no matter how elaborate or complicated, are combinations of what the physicist refers to as *simple machines*.

The *pulley*, the *wheel and axle*, the *inclined plane* (ramp), the *wedge*, and the *screw* are all simple machines. These machines serve any of the following three purposes.

They increase speed. Example: an egg beater.

They increase force. Example: an automobile jack.

They change the direction of a force. Example: a single pulley.

It is important to understand that these simple machines do not produce energy but make use of the energy supplied to them.

In this section we have grouped together a number of simple machines which use the wheel as one of their parts: *pulleys*, *gears*, and the *wheel and axle*.

Pulleys

The pulley used to raise a flag to the top of a flagpole is called a *fixed pulley*. Fixed pulleys are also used in raising hay into barns, raising sails to the tops of masts, and hoisting materials from the ground in the construction of buildings. A fixed pulley makes it more convenient to apply a force since it is usually easier to pull down than to lift up. One reason for this is that the weight of the person helps pull the pulley rope. However, a fixed pulley does not increase the force. As much force is required to pull down on the rope as to lift the weight without the pulley.

(Actually, a bit more force is needed because of friction between the rope and the pulley wheel, and between the pulley wheel and its axle.)

A combination of several pulleys, in which one or more not only turns, but also moves in relation to the other pulleys, is called a *compound pulley*. Compound pulleys magnify force. Using the pulley shown in the illustration, a man can lift a 100-pound weight with a 50-pound pull, if the loss due to friction is disregarded. Does this mean that we are getting something for nothing? No, since the man must pull the rope 2 feet to hoist the weight 1 foot.

Each combination of pulleys is called a *pulley block*, and the arrangement of blocks and their ropes is called a block-and-tackle.

Gears

Force can be transmitted from one wheel to another by equipping both wheels with intermeshing teeth. Such wheels are called *gears*, or gear wheels.

The egg beater, which is described in *Problem 7*, is a good example of a device which uses gears. In a common egg beater, one turn of the large wheel which is moved by the hand results in five turns of the small wheel which is connected to the beater. Gears thus make it possible to operate the egg beater rapidly. The gears in an egg beater also change the *direction* of the force. It is more convenient for your hand to circle in a vertical plane while the beaters swirl in a horizontal plane.

Sometimes, as in a bicycle, the two wheels are connected by a chain. The front gear wheel, where the force is applied, is larger than the one fastened to the rear wheel. One turn of your foot on the pedals results in several turns of the bicycle wheel. Here, again, *speed* is gained by an investment of force exerted against a large gear which moves a smaller one.

Wheel and Axle

A doorknob is a wheel which is part of a simple machine called a *wheel and axle*. The axle is the part which goes into the door and turns the mechanism which opens it. One has only to try to turn the axle after the doorknob has been removed to appreciate the value of this machine, which is a force-multiplying device. A little force applied to the rim of the knob will cause a greater force to be exerted on the axle. Here again, as in all other machines, we do not get something for nothing. To turn the outer edge of the *axle* through a distance of $\frac{1}{4}$ inch, for example, one must turn the outer rim of the knob (the *wheel*) through a distance of about 1 inch. Force is gained, but at the cost of greater distance.

In some wheel-and-axle machines the *wheel* is reduced to a single spoke or handle. Some examples are the pencil sharpener, meat chopper, pepper mill and wall can-opener.

Approaches and Learnings for the Child

In *Grade 3*, children found that wheels made our tasks easier by reducing friction. Now they see the usefulness of wheels in a number of simple machines. They experiment with pulleys to discover how these devices help move things more easily. They learn how belts and chains can make one wheel turn another. They investigate wheel-and-axle machines such as pencil sharpeners. They find out about the special uses and advantages of toothed wheels or gears.

In part of this work children use measurement as a tool of investigation. Thus their muscles tell them that a combination of pulleys make it easier to lift a heavy weight. By using spring scales they find out just how much easier the job is. By comparing the distance the pulled rope is moved with the distance the weight is moved, they see that they do not get something for nothing: although less force is needed, the child must pull his rope through a greater distance than the weight is moved.

From the activities suggested, children learn the following.

Wheels are found in many machines.

The pulley, gear, and wheel and axle make it easier to move things.

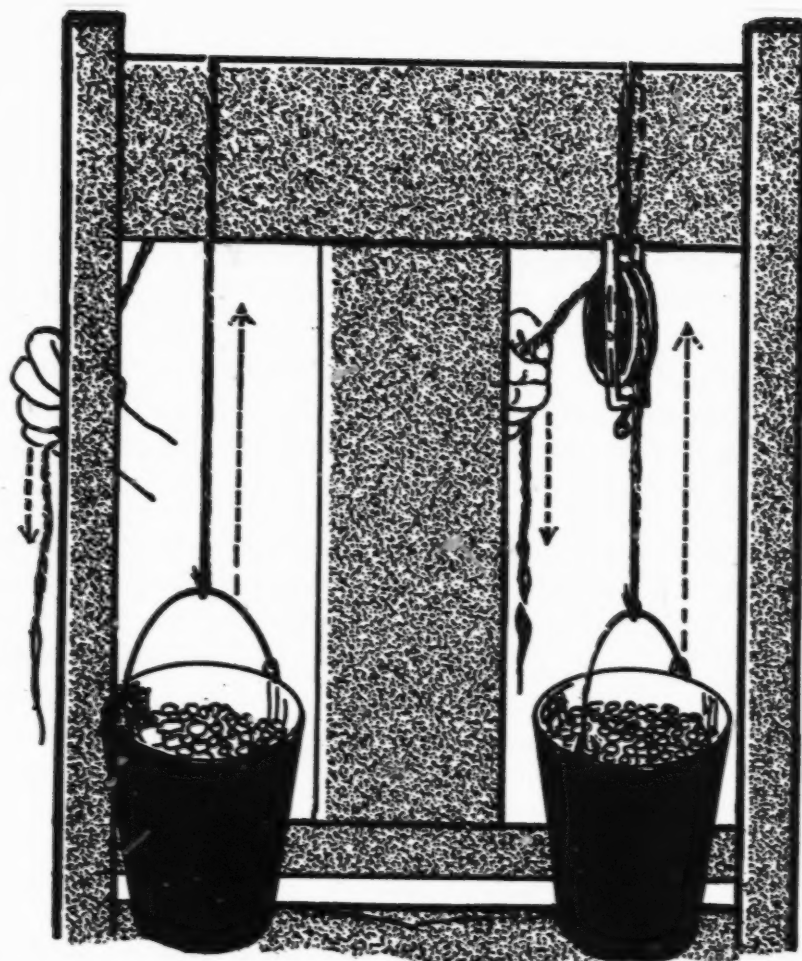
1. How does a pulley help in raising a flag?

Children have seen our national flag flying on or near the school building. Ask them how they think the flag was placed so high on the pole. Could this be done without a pulley, that is, without the rope and wheel? They will suggest that someone would have to climb the pole each time the flag is to be raised or lowered.

Use the small pulley, available from the E-1 List, to construct models of flagpoles, hoists, or other devices that use pulleys. How does the wheel in the pulley help? Try pulling a load over a table edge or a chair back. Use a rope, but no wheel. Compare with the effort needed when a wheel is used. See illustration, page 258.

Have children find pulleys used in their neighborhood: on clothes lines, on window sashes, on buildings under construction, on ash-can hoists.

How does the pulley help in each case?



It's easy with a pulley.

- The wheel in the pulley makes it easy for us to move the rope.
- With a pulley, an object can be moved up by pulling down on a rope.

2. How can a man hoist a piano up the side of a building?

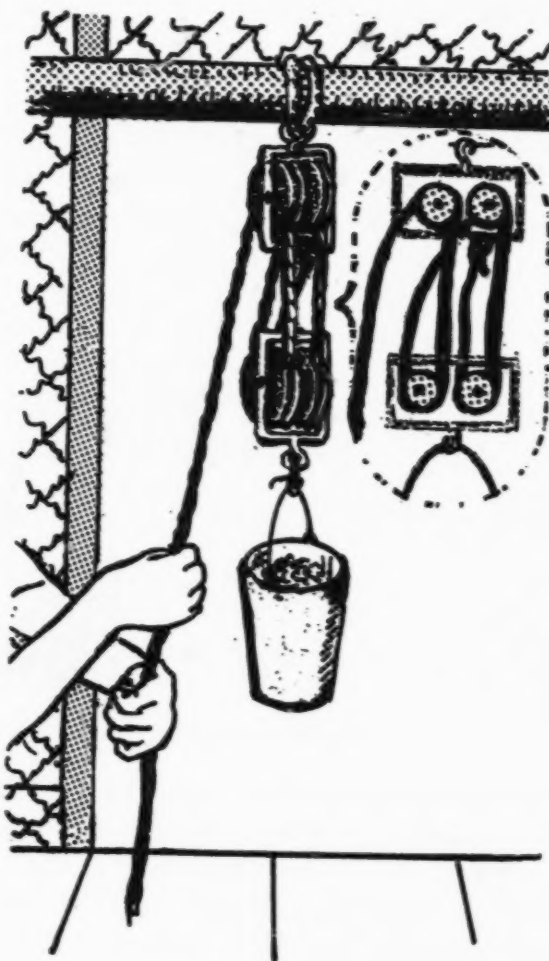
Children may have observed piano movers at work. Or perhaps they have seen men hoist themselves up while on a scaffold. How is it possible for men to lift such heavy loads? In both of these cases, children will recall that a pulley arrangement (combination of wheels and a rope) is used. Such an arrangement is called a *block and tackle*. (The block refers to the framework and the grooved pulleys.)

Have children experiment with a pair of double pulleys to determine how effective an aid they are in lifting heavy weights. Attach one double pulley to a sturdy support such as a hook on the frame of the chalkboard, or to a horizontal support in the schoolyard. Thread strong cord of suitable thickness through this pulley block and then through the other

one, as shown below. Securely attach a load, such as a briefcase or a toy pail full of sand, to the hook on the lower pulley block. The children lift the weight by pulling on the cord. Compare the force needed to raise the load this way with the force required to raise a load of equal weight without the block and tackle.

How much easier is the job? To answer this question it will be necessary to make a measurement. A spring scale may be used to weigh the load to be hoisted. Then attach the spring scale to the end of cord that will be pulled to lift the weight. As one child pulls on the ring at the end of the scale, the other reads the scale. How do the two readings compare? Repeat the experiment, but use different weights. Children discover that in each case the effort is less than the weight of the load.

- *A heavy load may be lifted easily with a block and tackle.*
- *A block and tackle is made of pulleys, a support for the pulleys, hooks, and a rope.*



It's easier with more pulleys.

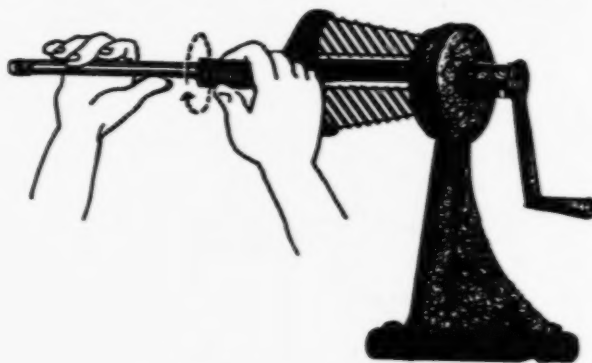
3. Does the block and tackle give us "something for nothing"?

From the previous problem, children may think that devices using pulleys and rope actually yield more than we put into them. To test this idea, lift the weight again with a block-and-tackle. Have children observe carefully to see if they can detect any evidence that the child who is pulling the rope is putting anything into the job which has not been considered before. Some children may discover that when the weight goes up one foot, the hand goes down four feet. They will conclude that although the force required is less, the child must use this force over a greater distance. They will also see a mathematical relationship between the force *advantage* and the distance *disadvantage*. That is, if the effort used equals half the weight of the object, the distance the hand moves that much weight is twice the distance the object moves.

- *The block-and-tackle does not give "something for nothing."*
- *When we lift heavy objects with pulleys, we use less force, but we pull over a greater distance.*

4. Why does a hand-operated pencil sharpener have a handle?

Have a child place a new pencil in the pencil sharpener and sharpen it in the usual way. Remove the waste container. Then have him sharpen another new pencil by turning the shaft without using the handle. Compare the effort needed in each case. (Caution children not to run their fingers over the cutting edges of the sharpener.)



It's easier with a handle.

The handle-and-shaft arrangement of the pencil sharpener is an example of what is called a *wheel and axle*. The handle might be considered one spoke of a wheel (it moves through a circle), and the shaft is the axle. Look for other wheel-and-axle devices. A doorknob is a good example. Others include the roller knob on a typewriter, the dial on a telephone, the steering wheel on a car, the handle on a faucet.

Some children may compare the wheel and axle with the pulleys in the block and tackle. They may suggest that the advantage of having to use less force is balanced by having to use this force over a greater distance. Determine this mathematically by measuring the distance around a doorknob. Compare this with the distance around the shaft.

- *A handle makes it easier to use such things as pencil sharpeners and faucets.*

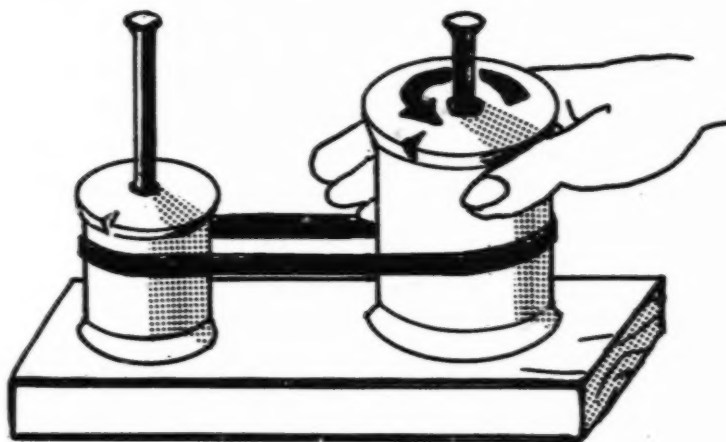
5. How is a belt used to make one wheel turn another wheel?

Ask children to tell of devices on which they have seen belts turning wheels. They may recall having seen them in construction sets, shoe repair shops, motion picture projectors, and automobiles (fan belt). The school custodian may agree to show the class how a belt is used to run ventilating machines in the building.

By means of the following homemade devices, children may discover some of the principles of the wheel-and-belt drives.

With two similar spools and a rubber band, set up a belt system. Make a mark at the top of each spool to be used as a reference point. Then have children turn one wheel to see the effect on the other. They learn that when both wheels are the same size they both turn at the same speed. They also turn in the same direction. However, if the belt is twisted into a figure 8, the driven wheel turns in the opposite direction to the driving wheel. Point out that a driving wheel may be turned by electric motors, steam engines, water wheels, or other devices.

The children should also experiment with belts (rubber bands) on small and large spools. Children will notice that while they turn the large wheel, (once) the small wheel turns faster (more than once). When they turn the small wheel, the large wheel turns more slowly.



Which wheel makes more turns?

Have children bring in pictures and report their observations of belts used on toys, machinery, and other devices such as tape recorders, vacuum cleaners, refrigerators, air conditioners, and automobiles.

- *A belt is used to make one wheel turn another wheel.*
- *When wheels of the same size are connected by a belt, they move at the same speed.*
- *When wheels of different sizes are connected by a belt, the smaller wheel turns faster than the larger wheel.*
- *Wheels connected by a belt move in the same direction unless the belt is twisted once.*

6. How does a bicycle chain help turn the wheels?



Pedal gear is larger than the rear gear: speed is increased.

Where practical, have children bring one or more bicycles into the classroom, the playground, or the basement. Turn the bicycle upside down so that it rests on the seat and handle bars. Turn the pedals slowly so that everyone sees how the chain engages the toothed wheels (gears) and turns the back wheel. *Note:* Do not permit the children to touch the chain or gears at any time.

Ask what the advantage is in using a chain and gears, as compared with a belt and grooved pulleys. The children should see that in this arrangement there is no slipping of the chain as it moves around both gears. Compare this with the slipping that occurs in a system of string and rubber-band belts around spools, as in *Problem 5*.

Attention should be called to the different sizes of the gears. With the aid of chalked reference marks, have children count the number of turns the pedal gear makes as compared with the rear gear. Children notice that the rear wheel turns several times while the pedal gear turns once. Determine the exact number of turns. This makes it possible to move faster on a bicycle than afoot.

- *Gears are wheels with teeth.*
- *With a chain belt, one gear can turn another gear without slipping.*
- *In a bicycle, speed is increased because the rear gear is smaller than the pedal gear.*

7. Why are gears used in egg beaters?

Have children inspect an egg beater. From their experiences with the use of an egg beater in their homes, they know that it enables us to beat eggs, cream, and other foods rapidly. How do their gears help? Make a mark on each of the gears. Turn the hand-driven gear one revolution and count the number of turns made by the stirrer gears. The children see that the stirrers move faster than the hand-driven gear. Why?

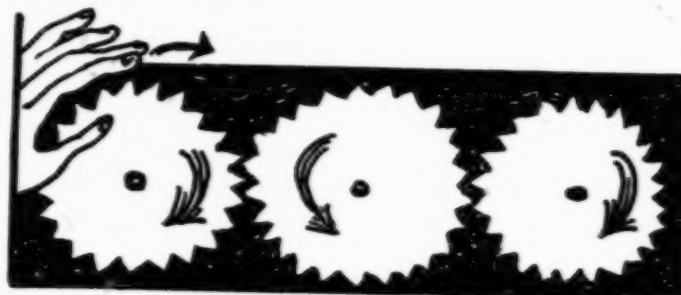
Some children may suggest counting the teeth in each of the wheels. They will discover that the large hand-driven gear has more teeth in it than the stirrer gear. They observe also that when the wheels move, the teeth engage each other. They may infer that as the hand-driven gear, with its greater number of teeth, makes one turn, the stirrer gear is forced to turn several times.

Ask the children if they can find a relationship between the number of turns of each gear and the number of teeth. If, for example, the hand-driven gear has five times as many teeth as the stirrer gear, then the stirrer gear makes five turns for every one turn of the hand-driven gear. Children will also discover that the position of the gear wheels changes the direction of motion, thus making the egg beater more convenient to use.

- *A large gear makes a small gear turn faster.*
- *Gears can change the direction of motion.*

8. Can we make our own set of gears?

Children can make these devices. Make three tracings of the large gear illustrated on page 264. Use the kind of thick cardboard which has corrugated board between two flat surfaces. Cut the gear teeth carefully. (The teeth on real gears are shaped somewhat differently than those on this model.) Make a nail hole in the exact center of each wheel as shown. Attach the gears with paper fasteners or roofing nails to the bottom of a shoe box or a similar box.



Assembling a gear train.



Making a gear.

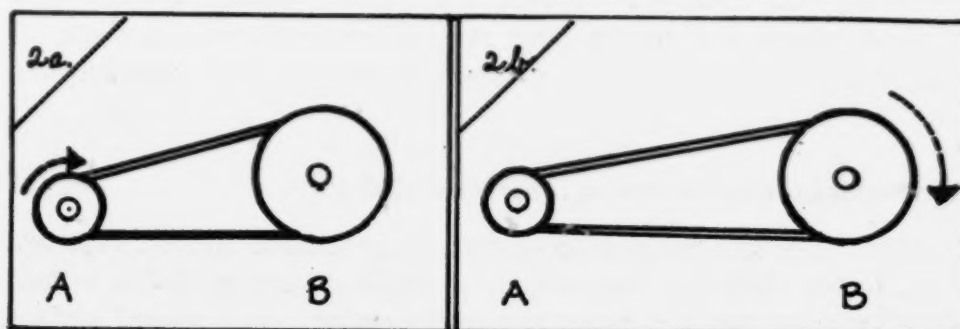
While experimenting, the children find that because these gears are all the same size, they turn at the same speed. When one gear is turned, they discover also, the gear it engages turns in the opposite direction. They also learn that the third gear moves in the same direction as the first. The words *clockwise* and *counter-clockwise* should be used here. Encourage children to construct variations of this gear arrangement (gear train) and to experiment with them. Thus some children may hook up more gears and some may vary the sizes of the gears.

An old alarm clock movement is excellent for observing gear trains in action. Another device showing gears in action is the heavy cardboard clock model containing gears, which is used in the mathematics program.

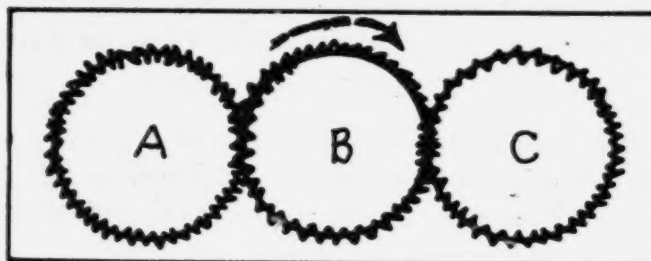
- *When one gear turns, the gear it engages turns in the opposite direction.*
- *Clockwise is in the direction the hands of a clock turn.*
- *To turn counterclockwise is to turn in a direction opposite to that of the hands of a clock.*

EVALUATIVE ACTIVITIES

1. Why does a farmer hoist hay into a barn with a rope and pulley? (Many answers are possible depending in part on the kind of pulley: he doesn't have to lift his own body up; it is easier to pull down than to lift up; the pulley makes it easier to lift a heavy load.)
2. Spool A and Spool B are each held to a board by a nail through the center. Each can turn easily.
 - a) Anna turns Spool A in the direction shown by the arrow. Show, with an arrow, which way Spool B will turn. (Same direction as Spool A.) Which spool will make more turns? (Spool A.) How could Anna make Spool B turn in the opposite direction to the way it moves now? (Turn Spool A in the opposite direction *or* twist the cord into a Figure 8.)



- b) Anna now turns Spool B in the direction shown below. In what direction will Spool A turn? Show with an arrow. (Same direction as Spool B.) Show by arrows how the cord will turn. Which spool will make more turns? (Spool A.)
3. a) In a bicycle a large gear wheel makes a small gear wheel turn (faster, slower.) (Faster.)
 - b) In an egg beater the large gear wheel (the one you turn) makes the small gear wheel (the one connected to the stirrer) turn (faster, slower.) (Faster.)
4. In the picture below there are three gear wheels. Show with your arms which direction wheels A and C will turn. (Both in opposite direction to B.) What name is given to the direction of B's turning? (Clockwise.) to the direction of A's turning? (Counterclockwise.) C's turning? (Counterclockwise.)



B. RAMPS HELP LIFT THINGS MORE EASILY

Background for the Teacher

If a man wants to lift a heavy barrel into a truck, he may roll it up some planks. He is using a machine called a ramp or, more properly, an inclined plane. This may be easier than lifting the barrel because at any one moment more of the weight is supported by the planks and less by his muscles. The inclined plane thus serves to make the job a more gradual one and consequently an easier one.

As in other machines, the worker must pay for his convenience by moving it over a greater distance. Instead of lifting the load straight up for a distance of 5 feet, for example, he pushes it for a distance of 15 feet up the ramp. It is believed that the huge blocks of stone used in the construction of the Egyptian pyramids were placed in position by being pushed by hand up long, sloping hills of earth made especially for that purpose.

Approaches and Learnings for the Child

Children have seen many places in the neighborhood where ramps are used. In the classroom they employ a simple measuring device to find out whether or not it is easier to move something up a slanted surface to a higher level than to lift the same object from the low place to the higher one.

From the activities suggested, children learn the following.

- *Ramps are used to lift objects more easily.*
- *Ramps are also used to slow the speed of objects moving downward.*

1. Where are ramps used in the neighborhood?

Ask children to look around the neighborhood and report where ramps are used and for what purposes. They may report observations such as the following. Ramps are used in construction jobs to make it easier for men and wheelbarrows to enter and leave buildings. Ramps enable trucks and bulldozers to move easily in and out of excavations. Ramps may be seen in theater lobbies, baseball stadiums, approaches to bridges, tunnels, and parkways. Hospitals may have ramps at doorways and curbs to make it easy for wheelchairs to be moved.

Discuss with the children the advantage of a winding road up a steep mountain. Some children might wish to illustrate this by constructing, of clay or other material, models of mountains with winding roads. They

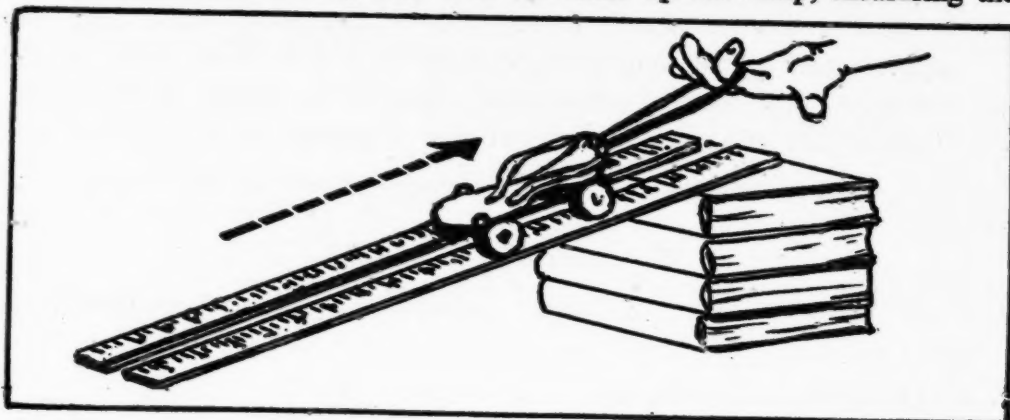
may bring in pictures of such roads or tell of hiking or motoring experiences on them.

In their search children discover that some ramps, such as coal chutes and playground slides, move things only from high to low places. Discussion might point out that such ramps slow the moving object to a safer speed.

- Ramps are used in many places to lift objects more easily.
- Ramps are used to slow the speed of objects moving down.

2. Is it easier to move something up a ramp than to lift it?

Have children bring roller skates to school. Attach a rubber band or a spring scale to the end of a skate or any other small object with wheels. Measure the force needed to lift the object vertically from the table to the top of some books, as shown by the length that the rubber band stretched or the number of ounces registered on the scale. Now set up a ramp from the table to the top of the same pile of books. Use a plank, or two yardsticks side by side. Pull the skate up the ramp, measuring the



Up the Ramp (Weight of skate ---- ounces)		
Number of books high	Inches of stretch of rubber band	Ounces of pull on spring scale
one		
two		

The steeper the slope, the harder the pull.

stretch of the rubber band or the ounces of force on the spring scale. Ask the children which method of raising the skate to the top of the books requires more effort.

Have children repeat this experience by changing the angle of the ramp, either by using a longer or shorter ramp or by taking away or adding more books. Have them prepare charts recording the length of the rubber band and/or the force in ounces on the spring scale as compared with the angle of the ramp. Draw conclusions about the effort used in relation to the steepness of the ramp. (A ramp is also called an inclined plane.)

- *A ramp helps us lift an object more easily.*
- *The steeper the ramp, the greater the effort required to move things up it.*

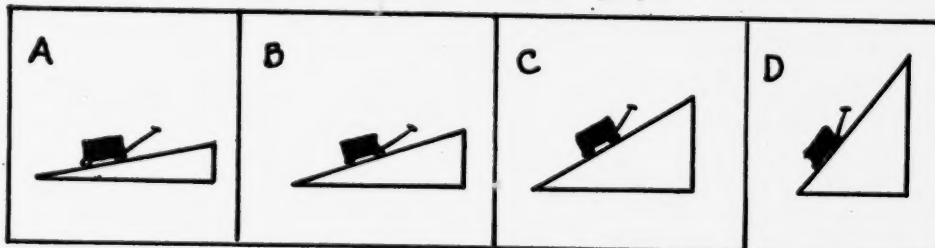
3. Why is it easier to move a load up a ramp than to lift it straight up?

From the previous experience with skates and rubber bands or spring scales, children have learned that the entire weight of the skate is supported by the finger when the ramp is not used. Why does the ramp make it easier to lift the skate? Some children may observe that the ramp supports part of the weight of the skate while it is being pulled up the incline. At any moment, consequently, there is less weight on the fingers. However, the effort must be exerted over a greater distance.

- *A ramp makes lifting easier by supporting part of the weight.*

EVALUATIVE ACTIVITIES

1. A toy wagon is pulled up differently slanted hills as shown in the illustrations below.
 - a) On which road would it be easiest to pull? (A.)
 - b) On which roads is gravity pulling on the wagon? (A, B, C, and D.)
 - c) Which road is most slanted? (D.)
 - d) If a rubber band is used to pull the wagon, on which hill would the stretch be greatest? (D.)
 - e) On which hill would the stretch be least? (A.)



C. LEVERS HELP MOVE THINGS MORE EASILY

Background for the Teacher

A child can give his teacher a lift if he has a *lever* that is long enough and a balancing block or *fulcrum* to place it on. The lever is a *simple machine* that is used in many familiar devices. The stout limb used to move a boulder, the hammer to pull a nail, and the crowbar to lift a crate are all levers.

To come back to the teacher-lifting machine, assume we have a plank six feet long with a block placed under the plank one foot away from the teacher's end. Assume also that the teacher weighs 125 pounds. How much force will the child have to apply to his end to lift the teacher? The answer is: only 25 pounds. The effectiveness of the child's muscles is thus increased five-fold. Also note that the child's end of the lever is five times as long as the teacher's end.

As in the machines discussed previously, we are not getting something for nothing. In order to lift his teacher 1 inch, the child must push down his end of the plank 5 inches. Force is lessened but distance is increased. In other uses of the lever, the position of the fulcrum or balancing point may be changed. Sometimes a lever may be used which gives *less* force than that which we expend. One example of this is in the fishing pole. Here the fulcrum is the butt end of the pole pressed against the fisherman's body. The force exerted by the hands is greater than the weight of the fish. However, the gain here is one of *speed*. The hand moves slowly but the fish is jerked quickly out of the water by a fast-penetrating hook.

Approaches and Learnings for the Child

Children have seen many kinds of levers in operation in the home, school, and neighborhood. Now they are ready to observe levers more closely and to experiment with them.

Children should be invited to look about them to discover how levers are used for different purposes and in different ways. In each case they should discover the particular advantage gained by the use of the lever. They should be able to locate three significant places on the lever: the fulcrum (turning point or pivot), the place where the user exerts his force, and the place where the object is pushed or pulled.

From the activities suggested, children learn the following.

With some levers, less force is needed to move objects.

With some levers an object may be made to move faster.

1. How can a lightweight child balance a heavyweight child?

Children are asked to recall their experiences on a seesaw. They tell how they are able to seesaw with bigger brothers or sisters. They may recall the different position taken by a playmate in order to balance the seesaw.

The children should realize that in order to balance a heavier child, a lighter child must sit farther from the fulcrum (turning point or pivot) than the heavier child.

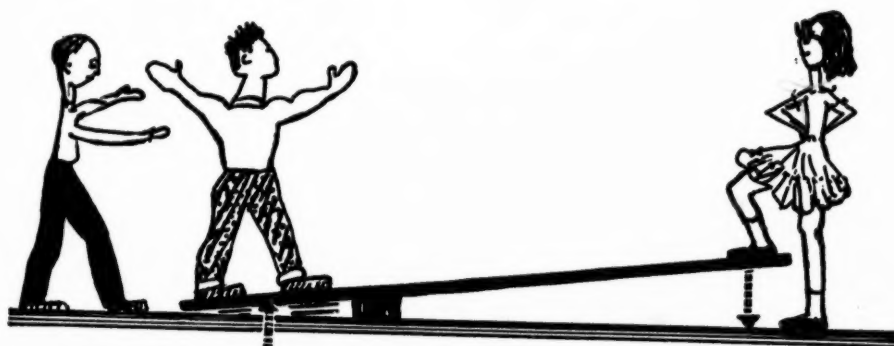
If a seesaw is available in the playground or park, have children of different weights experiment with balance. (Be careful *not* to embarrass an obese child or one who is undersized.)

- *By sitting farther from the fulcrum, a lightweight child can balance a heavyweight child on a seesaw.*

2. How can one child lift another easily?

Ask how one of two pupils would lift the other off the ground. The class will see that this is not an easy task. Now ask the class how this job could be done more easily by using material available in the classroom. Display a strong, rigid plank about eight feet long and ask how this can be used to lift a child off the floor. Some children may recall their experiences on the seesaw and suggest using the plank as a seesaw.

Place the board over two or three books or a block used as a fulcrum. Put the fulcrum much closer to one end. Have one child stand on the short end of the board. Have the other child press down the raised end of the plank. Be sure the first child *holds on to another person or to a wall* to keep from toppling over when he is lifted off the floor. Ask the children to observe the ease with which one child lifts the other. Also ask them to compare the distance each child moves.



It's easy with a lever.

A plank used with a fulcrum in this way is called a *lever*.

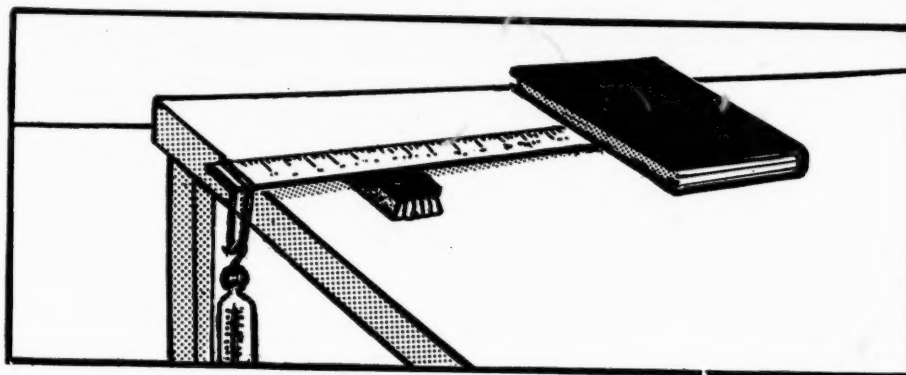
- *By using a lever, one child can lift another with little effort.*
- *To lift a child a few inches off the ground with a lever, we have to push the other end of the lever down many inches.*

3. What happens when we change the position of the fulcrum?

Balance an 18-inch ruler at its 9-inch mark using a chalkboard eraser as a fulcrum. Let the 1-inch mark on the ruler extend over the edge of the table. Place a book on the 18-inch end of the ruler. Press down on the other end: the book is raised.

Ask the children to suggest some way to measure the amount of force needed to raise the book. Some children may suggest pulling the free end of the ruler down with a spring scale and measuring the force.

Now place the board eraser under the 12-inch mark of the ruler. Leave the book on the 18-inch mark. Again have a child raise the book by pulling down on the scale. What is the reading? They observe that the pull is smaller than in the first case.



The position of the fulcrum (eraser) makes a difference.

Now place the board eraser closer to the free end (at 6 inches). Have the children repeat the experience and measure the force again. Now the pull is greater than in the first case. Make a chart to show the results of the various experiments.

The children should note that the location of the fulcrum of a lever affects the amount of force needed to lift an object with the lever. The closer the fulcrum is to the object, the easier it is to lift it.

- *The fulcrum of a lever can be located at any part of the lever.*
- *When the position of the fulcrum is changed, the amount of force needed to lift an object is changed.*



Another way to use a lever.

4. How can we lift a child by pulling up on the end of a lever?

The children will recall, from *Problem 2*, that one child can raise another by pushing down on a plank which is balanced on a wooden block or a pile of books. Ask the children to suggest a way of lifting someone easily by pulling up on a lever. Some children may suggest that the person stand on the plank close to one end. Then he may be raised easily by lifting the other end. (To avoid catching the fingers between the plank and the floor, use a rope to pull up on the plank.) Children note that in this use of the lever, no books are used to form a fulcrum. The fulcrum is at the end of the plank in contact with the floor. The children should also compare the distance moved by the hand of the lifter and by the person being lifted.

- *The fulcrum may be located at one end of a lever.*
- *A person can be lifted easily if he is close to the fulcrum of a lever.*

5. How many levers can you find?

Have the children conduct a search for levers by looking around the schoolroom or building, outside the school, or in their homes. It may be desirable to review with the children some of the concepts they learned about levers in previous activities. Also point out that levers may come in all sizes. Many tools are levers or combinations of levers.

The following chart lists some common levers. It should be used only to help children obtain a better understanding of levers. In it, Δ indicates fulcrum; $\rightarrow$ indicates where we push; or pull; - - - - $\rightarrow$ indicates where the lever pushes or pulls.

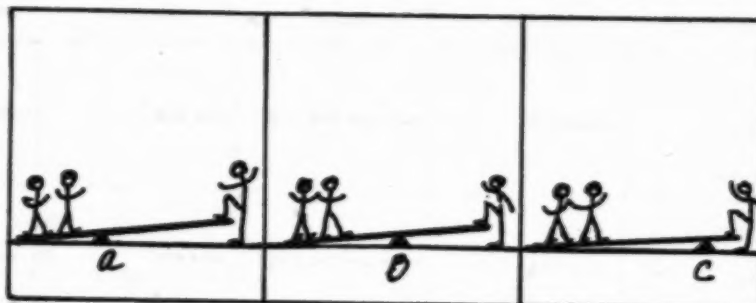
The children should note that with most of these levers, less force is needed than would be required without them. However, in using these levers, the hands or fingers move through a greater distance.

With some levers (starred * on the chart), more force is required with the lever than without the lever. In such cases, the greater force is used in order to gain speed.

EVERYDAY LEVERS				
Found in	Used for	Location of fulcrum	Where we push or pull the lever	Where the lever pushes or pulls the object
 seesaw	balancing	between the ends	one end	opposite end
 balance (scale)	weighing	between the ends	one end	opposite end
 claw hammer	pulling out nails	head of the hammer	end of handle	claw
 pliers	gripping (2 levers)	between handles and jaws	handles	jaws
 crowbar	prying	near one end	far end	end near fulcrum
 scissors	cutting cloth or paper (2 levers)	between handles and blades, closer to handles	handles	blades
 nut cracker	crushing shells of nuts (2 levers)	hinged end	handles	between ends, closer to fulcrum
 paper cutter	cutting	hinged end	handle	between the ends
 *oar	rowing	oarlock	handle	blade
 *fishing pole	fishing	grip (handle)	between handle and tip	tip of pole

EVALUATIVE ACTIVITIES

1. In the illustration below, A, B and C are fulcrums. Which fulcrum should be used so that the girl can lift the two children most easily? (A.)



2. What levers are there in your home? (Do children name any in addition to those studied in school?)
3. If you wanted to move a big rock, which of the following illustrations shows the best way to place the lever? (C.)



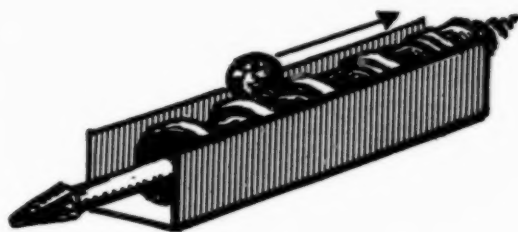
D. MORE THINGS TO DO WITH WHEELS, GEARS, PULLEYS, RAMPS AND LEVERS

This section lists special projects for interested students. The children should be encouraged to present their findings and demonstrations to the class and to use them in school exhibits and science fairs.

The library is a rich source of ideas and inspirations. Refer interested students to the books listed in the Bibliography, pages 335-336.

1. Find out how houses are moved on rollers. Demonstrate the techniques used.
2. Find out how rollers and wheels are used in steel mills, paper mills, and in shoe-repair shops.
3. Show how water wheels are used in mills for grinding grain, and in turbines for generating electricity.

4. Find out what kind of gears were used in old windmills. Make models.
5. Find out how a windlass is used on a tow truck to lift a car, on a ship to raise the anchor, on a well to raise a bucket of water.
6. Find out how the Indians moved things. Did they use wheels? What is a travois? What machines or methods did ancient people use for moving things? For example, how were the huge stone blocks raised into position for the pyramids?
7. Make a model of a boat to show how a rudder works.
8. Find out how Robert Fulton's steamboat was operated.
9. In what ways is friction reduced in an automobile?
10. Find out the uses of a wedge. (A wedge consists of one or more inclined planes.) Show why a chisel, saw, pin, front tooth, woodpecker's bill, axe, and knife enter materials more easily.
11. Show, by making a balance scale from a yardstick, how a lever can be used for weighing things.

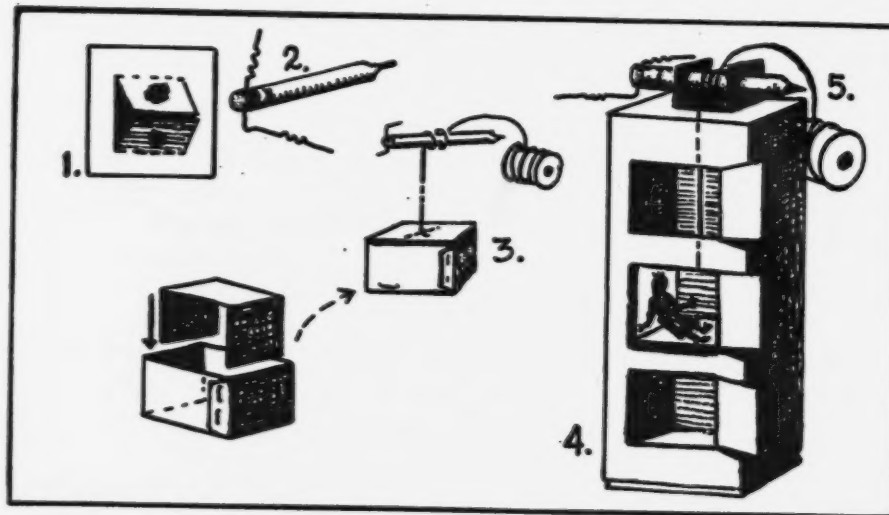


A screw conveyer.

12. Make a screw conveyer by placing a marble on a large auger bit in a cardboard trough. The marble will move forward as the bit is turned. Use a folded piece of oaktag as a trough to prevent the marble from leaving the bit as it progresses.

13. Use the wheel-and-axle principle to help lift a toy pail full of water. (Tie one end of a string to the pail handle. Wrap the other end around the shaft of a pencil sharpener. Turn the shaft to lift a pail.)
14. Study and sketch the pulleys used in a derrick.
15. Measure how far one goes when two paces are taken on foot. Compare this with the distance a bicycle wheel goes when two "steps" are taken on the pedals. Discuss the reasons for this.
16. Examine a hand-cranked grindstone to study the gears.
17. Use bottle caps to illustrate how gears work. Place caps, tops down, close to each other on a wooden board and drive a nail through the center of each cap. Move one cap and the one it engages will turn.

18. Make the model elevator shown in the illustration. 1) Cut a large H on bottom of milk carton and fold back resulting flaps. 2) Punch holes and insert pencil. 3) Make elevator car. Attach string. 4) Cut doors in carton, each 2¼" high. 5) Wrap string twice around pencil and attach to spool (counterweight).



Making a model elevator.

BASIC SUPPLY LIST FOR MOVING THINGS MORE EASILY

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

- | | |
|---------------------------|-----------------|
| 2 single Pulleys | 2 Tackle Blocks |
| 2 pairs of double Pulleys | 1 Spring Scale |

G-1: General Supply List

- | | |
|-----------------------------------|---------------------|
| *1 hand-operated Pencil Sharpener | 6 Paper Fasteners |
| 4 Rubber Bands | 1 Ruler, 18" |
| 1 Egg Beater | 1 Chalkboard Eraser |
| 1 large Nail | |

Miscellaneous

- | | |
|---------------------------------------|------------------------------------|
| 4 small similar empty Spools | *1 Plank, 8' long |
| 4 large similar empty Spools | *1 old Alarm Clock movement |
| *1 Bicycle | 3 pairs Roller Skates |
| 2 empty Shoe Boxes | 2 Yardsticks |
| 1 sheet of thick Corrugated Cardboard | 4 yds. Clothes line or heavy Twine |



The Water We Use

A. THE WATER WE DRINK

Background for the Teacher

Water, one of our most precious resources, is also our commonest and cheapest. The supply of water on our planet is ample; the problem is to obtain the right amount of fresh water in the right place at the right time. The *watershed* is of great significance in relation to this problem.

Sooner or later, much of the water from rain or snow appears as streams. Small at first, these upland water courses become wider and deeper as they approach valleys, where they combine to form larger streams and rivers. The area producing the water that appears as a stream or river is a watershed. Watersheds are of many shapes and sizes. Some cover millions of acres, like the Columbia and Missouri river drainages.

We depend not only on the surface water that we can see and measure in streams, lakes, rivers, and reservoirs, but on underground water, that is, water that is some distance below the ground level. Underground water begins as rain that sinks into the ground and then soaks into porous rock. As rain continues, the bottom rock layers become filled or saturated with water. The upper level of this underground water is called the *water table*. Ground water keeps moving along on the underground layers of rock. Eventually it may emerge into a lake, pond, or river.

New York City collects run-off water from a number of watersheds (see page 283) and stores it in large reservoirs. (Some water from the Hudson River is now being purified at the Chelsea pumping station and stored in some reservoirs.) Because our reservoirs are usually located at altitudes higher than New York City, the water flows downhill to us through large pipes called aqueducts. To supply tall buildings with water, pumps are used to lift the water to the roof where it is stored in tanks. The water in these buildings runs down pipes to each floor by gravity.

One of the main problems, especially in large cities, is the protection and conservation of water supply. Chemicals, such as chlorine, are used to remove harmful organisms from it. We aerate it to improve its taste.

Recently, New York City water has been fluoridated to help in the prevention of tooth decay, particularly in children.

Good drinking water is becoming harder to get in many parts of the country. Each community must find ways of preserving this precious material, and of finding new sources of it. In some parts of the country, sea water is now being processed to produce fresh water for industrial, agricultural and home use.

Approaches and Learnings for the Child

Children *make models* to simulate the valleys, hills, soil, and rocks of natural terrain, and splash water on the models to see how water washes down into "streams" and "lakes." They *look* for places in the neighborhood where the work and travels of rainwater may be seen. They *experiment* to find out how rapidly water sinks into different kinds of soils. They *read* to obtain information about New York City's watersheds and reservoirs. They *investigate* their own homes to look for leaky faucets, and *use mathematics* to determine how much might be lost from one leaky faucet in a 24 hour period. All these activities should help make children more conscious of the need to conserve water.

The publication *Operation New York* will be helpful in utilizing neighborhood resources for this study.

From the activities suggested, children learn the following.

Our water is collected outside our city from wide, sloped areas called watersheds.

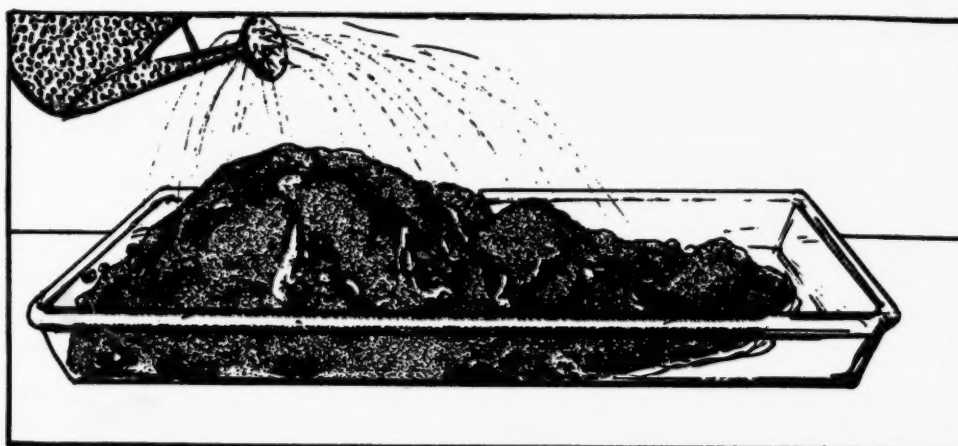
Huge aqueducts bring the water to us from distant reservoirs.

Our drinking water tastes good and is free from germs.

We must do our best to use water wisely.

1. What happens to rainwater when it strikes the ground?

Children are asked to recall their experiences with rainwater. Some may say that rainwater sinks into the ground. Others may have noticed that rain collects in puddles in some places. Several children may report that some rainwater does not sink into the ground quickly; it flows downhill, forming little streams. Running water often gouges out deep ruts, especially on hillsides. Other recollections may also be elicited: mud splashing against buildings; small rocks being carried by fast-moving rivulets; formation of flood areas, causing damage and inconvenience; deposits of mud after rainwaters recedes.



Flowing water carries soil and rocks.

Have children make a clay model of a hilly terrain, including valleys and depressions to simulate the natural terrain. Then place soil and rocks on the model. Using a watering can to simulate rain, children may see that the water from the "rain" washes loose earth and rocks down into "streams" and "lakes."

Children should be encouraged to look for and report on places in the neighborhood where the work of flowing rainwater may be seen. Class trips may be planned to visit such places.

The interest resulting from discussion and observation of rainwater may lead children to conduct some of the investigations and experiments in the following problems.

- *Rainwater may form streams which run downhill.*
- *Rainwater may sink into the ground.*
- *Rainwater often collects in puddles.*
- *Flowing water can carry soil and rocks.*
- *Uncontrolled rainwater can cause damage.*

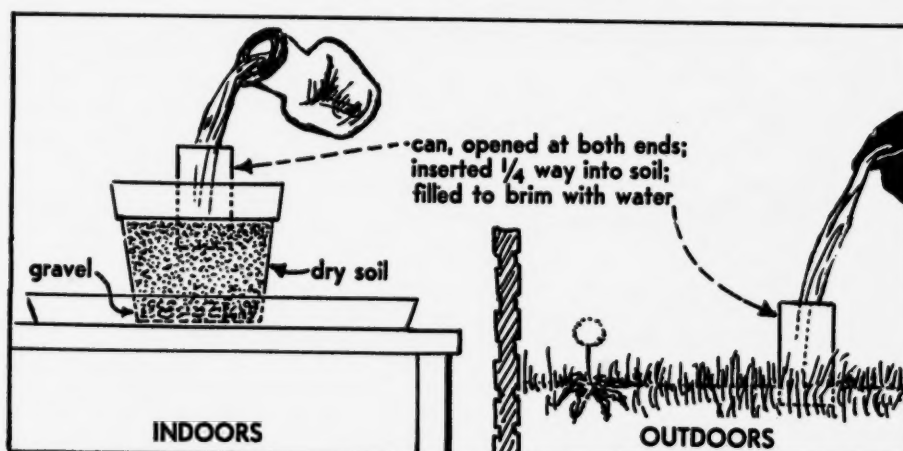
2. What happens when snow and ice melt?

In addition to rain, much of the water we drink comes from melting snow and ice. When these melt, the resulting water runs down the mountains and hills to form streams, rivers, and lakes (see *Problem 1*).

To see how this takes place, have children place ice cubes and "snow" on the model of hilly terrain used in *Problem 1*. Use ice cubes and "snow" from a freezer which needs defrosting, or from outdoors if available.

What happens to the streams and lakes if too much ice and snow melt?

- *Melting ice and snow may form streams which run downhill.*
- *Melting ice and snow may sometimes cause floods.*



Using an open-ended can to determine how fast water goes into soil.

3. How fast does rainwater sink into the ground?

Ask the children how to find the answer to this question. Opportunities should be given to try out their suggestions.

One method is to pour a full glass of water on the surface of soil. The children use a watch, and record the time at the start and also at the time the water is no longer on the surface.

A more reliable method is to use a small can which has been opened at both ends. Set one end firmly into the soil for a short distance. Pour in water to the brim of the can. Start timing. End the timing when no more water is in the can. This quantitative method is excellent for comparing different kinds of soils, or soils under different conditions.

Tests may be made indoors with soil, samples in containers, or outdoors on lawns, hillsides, or in vacant lots. In the case of indoor experiments, the original moisture content of the samples to be compared should be the same. One way to do this is to allow the soils to dry for several days.

The following problems may be investigated.

How fast does rainwater sink into loosely-packed soil as compared with hard-packed soil?

Does a sandy soil absorb water faster than soil with less sand?

How fast does a clay soil absorb rainwater as compared to ordinary soil?

Does water sink into bare soil as fast as it does into grassy soil? (Use the same soil for both pots. All conditions must be the same, except that

How fast does water go into soil?	
Kind of soil	How long it took
packed	one minute
loose	
sandy	
clayey	
grassy	

one pot has had some grass seeds planted in it several weeks before testing.

Ask the children to suggest other tests dealing with soil and rainwater. Discuss each experiment before it is performed. Point out the value of careful planning so that conclusions become meaningful. Are we really testing what we wish to test? What controls or safeguards shall we use?

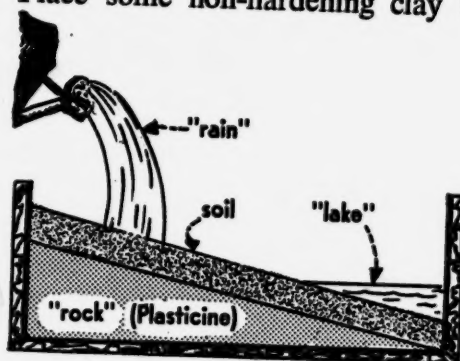
- Rainwater sinks into different kinds of soil at different speeds.

4. How can water run and collect underground?

Ask the children what they think happens to rainwater which sinks into the ground. They may already know that the soil can soak up some water. But what happens after the soil is soaking wet?

As more and more water is added, the unabsorbed water may sink into the ground. At a certain depth the soil ends, and the water strikes rock. If the rock is not porous, water will accumulate on top of it. If the rock is slanted, the water runs downward on it. The water may emerge farther downhill as a stream. It may also feed a lake and raise its level. This can be shown by setting up a demonstration.

Place some non-hardening clay (Plasticine) at a slant in a fish tank.



Water can run underground.

Press the clay against the glass sides. Lay some soil over the clay. Slowly sprinkle water over the soil. As the earth becomes saturated, the water can be seen sinking down to the "rock" layer. The water flows down to a "lake" and raises its level. Point out that one cannot see the underground water entering the "lake."

If the "rain" is sprinkled on the soil too fast or too heavily, the class may also observe how surface run-off can feed a lake. *Surface run-off* refers to the water which flows on the surface of the soil.

- *Underground water sinks down until it strikes solid rock.*
- *If the rock is slanted, the water flows downhill.*
- *Some rainwater runs downhill on the surface of the soil.*
- *Underground water may appear on the surface as a lake or a stream.*

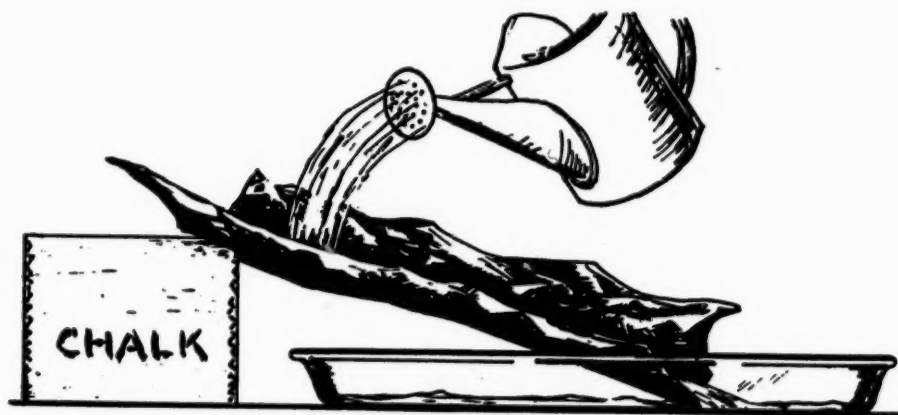
5. How does water get into a reservoir?

Ask the children what a reservoir is (a large place which holds water for present and future use). "How do you think the water gets into a reservoir?" Direct rainfall accounts for only a small part of the total supply in a reservoir. Most of the water in a reservoir flows into it from the sloping land surrounding it. Water, which originally fell as rain or snow on many thousands of acres surrounding the reservoir, is carried into it by brooks and underground streams.

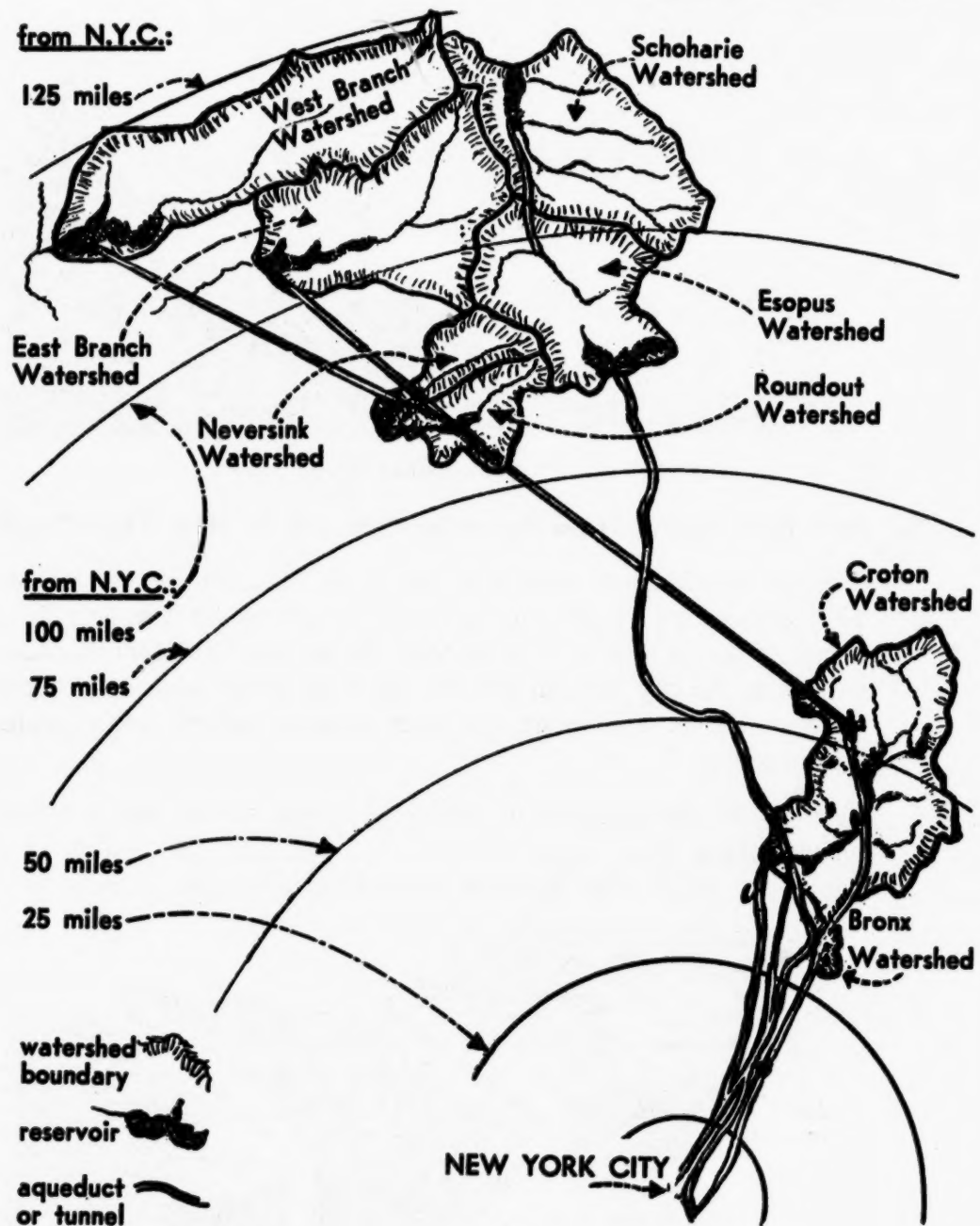
Land which slants toward a reservoir is called a *watershed*.

A demonstration to show how a watershed collects rainwater from a large area can be performed with a large sheet of aluminum foil.

Crumple the material, then unfold it and crease it lengthwise. Raise one end of the material by resting it on a box. Sprinkle water over the entire surface. The children will notice that the run-off of the rainwater is toward the center crease, as well as toward the bottom. Here and there, the water collects in small "lakes" and "ponds." After a while the water collects in the lowest part of this slant. Point out that in a real watershed area, this is where engineers would build a reservoir.



Aluminum-foil model of a watershed.



Some of the watershed areas that supply New York City.

A reservoir may be a natural lake or it may be a valley which has had one or two sides dammed or walled up.

- Water enters a reservoir because the land slopes towards it.
- Because of its size and slant, a watershed conducts much rainwater into a reservoir.
- A dam is used to hold back water in a reservoir.

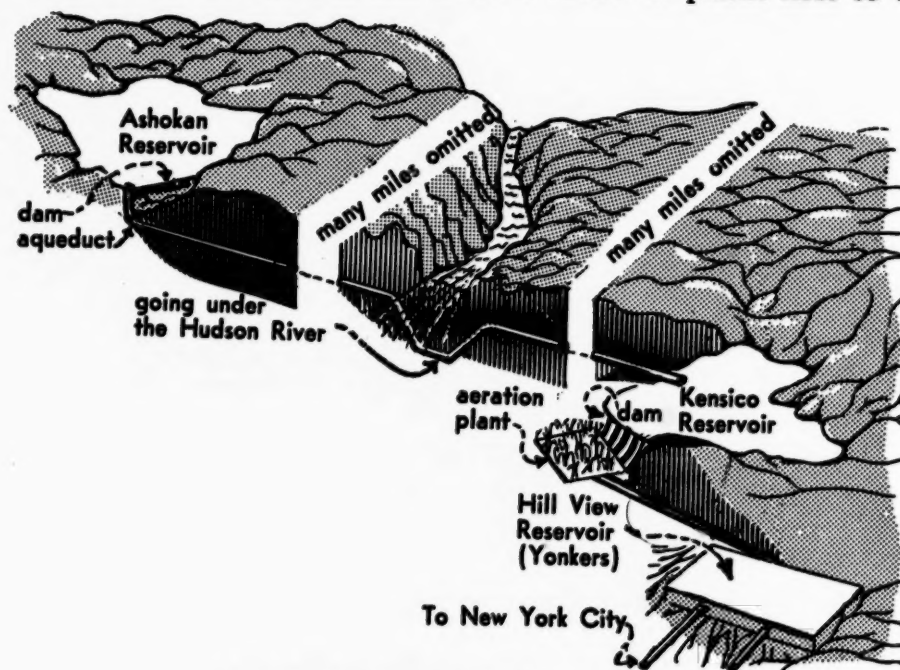


A watershed area.

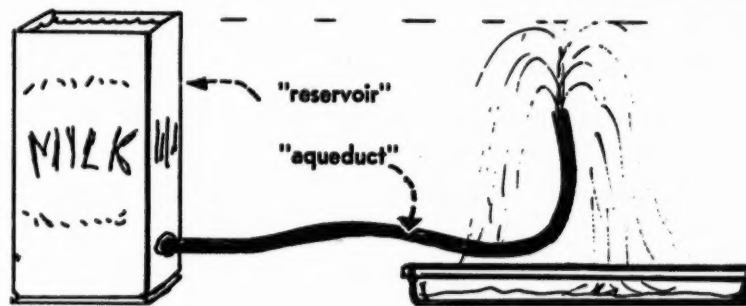
6. How does water from the reservoirs get to New York City?

Children should know that New York City is practically at sea level. They also are aware that our reservoirs are above sea level in hilly and mountainous areas of New York State. Water flows downhill, because of gravity, to the city through tunnels and pipes called *aqueducts*. Because of the difference in elevation, the water comes to our city under considerable pressure.

This can be demonstrated by means of a milk carton and a length of rubber tubing. Use a pencil to punch a hole near the bottom of one side of the carton. Into this hole insert a rubber or plastic hose so that



Aqueducts carry water to our city.



Water can rise to the level of its source.

it fits tightly. Make the connection between hole and hose watertight by wrapping non-hardening clay around it.

While filling the carton with water, be sure to hold the end of the hose above the top of the carton. The children will see that no water comes out of the hose. But, as the end of the hose is lowered below the level of the water in the carton, there will be a flow from the hose (into a handy basin). Raise the hose and the flow stops. Stretch out the hose so that the end is at a distance from the carton. Does this make any difference? Continue adding water so that the level is maintained.

The children should experiment with several similar models. Every child should be aware that the carton represents the reservoir "up in the hills," the hose represents the aqueduct, and the end of the hose, a faucet.

However, once the water arrives in the city, pumps are frequently used to increase or regulate the pressure. Tall buildings have water pumped up to water tanks placed on the roof tops. Ask the children to look for these water tanks. From there the water flows under pressure down to the faucets in the house.

- *Water from reservoirs comes to our city because gravity pulls water downhill.*
- *A large tunnel or pipe carrying water is called an aqueduct.*
- *Water in pipes can rise as high as the level of the reservoir which feeds the pipes.*
- *Pumps are needed in water towers and tall buildings to help push the water up into high tanks.*

7. How does settling help make our drinking water clearer?

Ask children whether they have ever scooped up cloudy or muddy water from a flowing stream. What is found in the water in brooks and other streams? (Sand, soil, gravel, bits of plants and animals.)

What happens to the particles in the still water when the water stops moving? (Particles sink and settle on the bottom.) Set up several dem-

onstrations in jars and milk bottles, by mixing some sand, earth, broken twigs, and small stones in the water.

The class will see that the heavier particles settle out first. In a few hours the water becomes much clearer. In several days the water should become fairly clear. Call attention to the settled material. There may be layers formed as different materials settle. New York City does not have special settling tanks or basins. Solid materials in our drinking water settle in the reservoirs.

- *When water moves, it carries along other materials.*
- *When water stands still, many of the materials in it settle.*
- *Water can be partly cleared by settling.*

8. How does screening help make our drinking water clearer?

Screens are placed at the outlets of reservoirs to prevent fish, leaves, twigs, and other debris from entering the water mains.

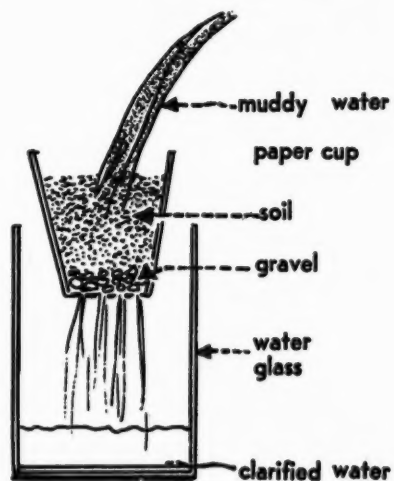
Have children prepare a mixture of water, leaves, bark, and other materials which might fall into a reservoir. They should pour this through a strainer and observe what is caught by the strainer, and what the water in the collecting vessel looks like.

- *Screening removes large objects from our water supply.*

9. How can we filter muddy water?

A filter is a device which holds back small particles. Perhaps some children may have seen a filter in certain coffee makers. They may also have observed the glass-wool filter in a fish tank. Paper filters are used by druggists and chemists. Absorbent cotton in a funnel can also be used as a filter.

To make a working model of a gravel-bed filter use a needle to punch small holes in the bottom of a paper drinking cup. Place a half-inch of fish-tank gravel on the bottom of the cup, over the holes. Cover the gravel with several inches of soil from a flower pot in the classroom or from a field or garden. Prepare some muddy water in a glass or jar. Slowly and carefully pour some of this muddy water into the filtering cup held over an empty glass. Do not pour from a height.



The water comes through clear.

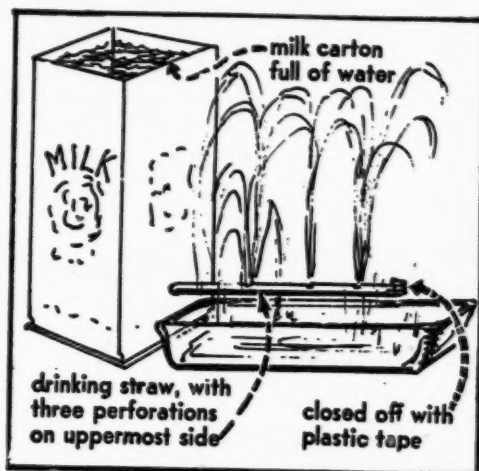
Compare the clarity of the filtered water with that of the unfiltered water. The children will be interested in the fact that mud can clear muddy water. *Note:* The water used by our city, unlike that of many other cities, is rarely filtered. There is no need to do so here. The above activity is included to show how filtering can be utilized when necessary.

- *Gravel and soil can serve as filters.*
- *Many materials can be used as filters.*

10. How is the taste of our drinking water improved?

Ask children whether they have ever swallowed drinking water which had a bad taste. Ask why this may have occurred. Perhaps the container or glass was not washed properly. Perhaps the water acquired an odor or taste from a nearby odorous material. Some children may recall that when water is left standing in a container for a long time it gets a flat or unpleasant taste.

Point out that water which remains in reservoirs for a long time may contain gases which spoil the taste. These gases come from living and dead plants and animals. When reservoir water is blown into the air through fine nozzles, the gases escape more easily. Spraying water into the air eliminates the flat taste also, by adding air to the water. This process is called aeration.



Make a model aeration plant as follows. Flatten the end of a drinking straw and bend it over. A bit of scotch tape will hold the crease securely. Make several pin holes in the top of the straw. With a sharp-pointed pencil make a hole in the milk carton as shown. Then force the straw into the hole so that the fit is watertight.

A model of an aeration plant.

Pour water into the carton. A fine aerated spray should issue from each hole. Also add a few drops of alcohol or perfume to the "reservoir." Have the children smell the air above the spray. The odor of the escaping alcohol or perfume will be quite apparent.

- *Aeration of drinking water removes ill-smelling gases and adds air.*
- *Aeration of drinking water improves its taste.*

11. How is our drinking water kept free from germs?

Show the children some clear tap water in a glass. Ask whether clear, clean-looking water is always fit to drink. If this water came from a well or from a stream in the country, might they question the water's purity? Why? Discussion should help the class realize that even clear water may contain germs, including certain disease-causing protozoans (one-celled animals) and bacteria. These tiny living things may live in the clear water but cannot be seen with the naked eye.

Using a microscope, with magnification of 100X, have children examine a drop of pond water and a drop of tap water. *Note:* At this magnification, bacteria are difficult to observe, but other simple forms of plant and animal life may be seen. Have children form conclusions as to which they would rather drink. How can we kill these bacteria and other harmful organisms to make the water safe for drinking? Some children may know that a good way is to boil the water, especially when camping or in unfamiliar places. Boil pond water and have children reexamine it under the microscope. (A substitute for pond water may be made by placing some grass or hay in a jar of water, and letting it stand for a week. Another is water from an aquarium in which plants and fish have been for some time.)

It is unnecessary to boil water in New York City. We *prevent* germs from getting into the water supply by preventing contamination with waste material. Moreover, the *Department of Water Supply* adds chlorine to the water as an extra precaution against certain kinds of bacteria. Children will recall having smelled chlorine in swimming pools and sometimes in drinking water. Put a few drops of a chlorine bleaching liquid, such as Clorox, in a glass with a little water. Move among the children with it so that the chlorine odor pervades the room.

- *We prevent germs from getting into New York City water.*
- *Impure drinking water may contain germs which cause disease.*
- *Chlorine is added to our water to kill germs.*

12. Why is New York City water fluoridated?

Ask children to report on the reasons for fluoridation. Many of them use toothpaste which contains fluorine compounds. They have heard of experiments which indicate that fluorine, when added to our food or drinking water or applied to the surface of our teeth in toothpastes or toothpowders, seems to prevent tooth decay. If possible, secure reports of these experiments. The public libraries will help. Emphasize the use of *controls* in these investigations (children under similar conditions who did *not* get fluorine), and the *large number* of individuals

GRADE FOUR

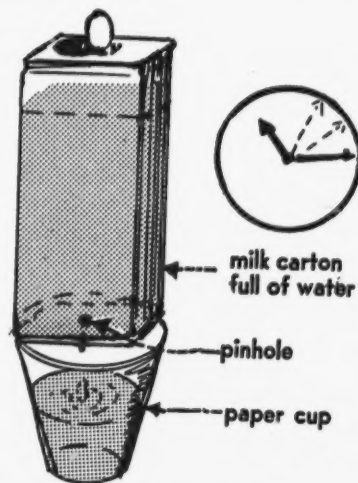
tested. The children should be led to realize that these are important in experiments, and necessary to provide a sound basis for a conclusion.

- *New York City fluoridates its water supply to prevent tooth decay.*

13. How can we conserve water?

Because of the recent years of drought in New York City, children are aware of the need to conserve water. See *Weather*, page 253.

Have children look around their homes for faucets which leak. Ask them to devise ways of finding out how much water is wasted by a leaky faucet in just one day. Try out as many of the children's suggestions as feasible.



Every little drip counts.

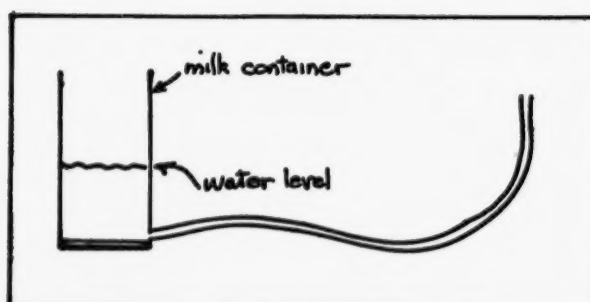
One method children may use to measure wastage is as follows. Make a small pinhole in the bottom of a milk carton. Fill the carton with water which slowly drips into the glass. Have children keep a record of the amount of time it would take for a quart of water to be wasted because of only a slow leak. Have children do the necessary mathematics to find out how much water a slow leak wastes in a twenty-four hour period.

- *Water is precious and should be conserved.*
- *We can conserve water by fixing leaks and turning valves tightly shut.*
- *A little drip can result in a lot of water waste over a period of time.*

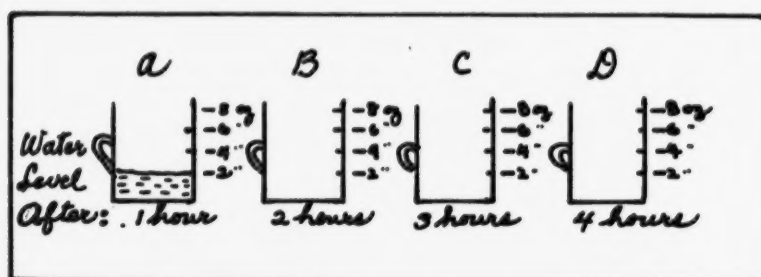
EVALUATIVE ACTIVITIES

1. Does the amount of snowfall during a winter have anything to do with our water supply? (Yes.) Why? (Snow in the watershed area melts into water which goes into our reservoirs.)
2. Is the water which sinks into the ground lost forever as drinking water? (No.) Explain. (It may run underground and fill a stream or a lake.)
3. *True or False*
 - a) The water we drink comes from the rain which falls in New York City. (False.)
 - b) Land which slants toward a reservoir is called a watershed. (True.)
 - c) Water can flow uphill. (True.)

4. Look at the illustration below. a) Show by a wavy line the level of the water in the tube. (Same as in carton.) b) What would you have to do to make water come out of the tube? (Either add more water to the milk carton, raise the milk carton, or lower the tube.)



5. Pictured below are four measuring cups. Cup A shows the amount of water lost from a dripping faucet after one hour. Show in Cup B how much water would be lost after 2 hours (4 oz.); in Cup C after 3 hours (6 oz.); in Cup D, after 4 hours (8 oz.).



6. Why are swimming pools chlorinated? (To kill germs; many people swimming together may add germs to the water.)
7. Ask children to report on ways of conserving water in their own homes.

B. BODIES OF WATER IN NEW YORK CITY

Background for the Teacher

It is important for us to appreciate the fact that the earth is an ever-changing place. Some scientists believe that in the beginning the earth was a red-hot molten mass. As the earth cooled, water vapor and other gases were released and rose into the atmosphere. Clouds formed and gathered and the first rains fell on Earth. Precipitation has been occurring since then. Water which has shaped the mountains, valleys, ocean beaches, and lake shores continues to change the face of the earth.

The shapes of the continents we know today were different millions of years ago when the oceans covered more of the earth. Future continents may have different shapes millions of years hence.

Plant and animal life apparently began in the warm ancient seas, and living things have not yet lost their need for water. Ponds, lakes, rivers, streams, and ocean beaches provide us with different kinds of communities of living things to observe. They also offer the observer evidences of many geological changes as water continues to shape the Earth.

Approaches and Learnings for the Child

It is important that children have the opportunity to explore some aspect of the natural environment *in its totality*. For this reason, four natural "scenes" around New York City are selected. One of these (or more, if this is feasible) should be visited: a park lake, a small stream, a harbor, an ocean beach.

As children investigate the areas, they begin to appreciate the interdependence of plants and animals and their environment. Children also uncover evidence of changes in nature. They see how man is affected by some of these changes. They begin to appreciate the importance of conserving the natural environment, not only for man's recreation but also for his survival.

If possible the lake, stream, harbor, or beach should be revisited by the children either as a class, or with their parents, in order to see the changes which occur with the succession of seasons. *Operation New York* will be most helpful in providing more leads to such studies.

From the activities suggested, children learn the following.

Many kinds of plants and animals live in water around New York City.

Moving water changes the surrounding land.

We must use our natural resources wisely.

1. What plants or animals live in or near a park lake?

A lake in a park is a place where children can learn conservation at first-hand. Such a lake may be natural or artificial, or a combination of both; it will certainly be different from a lake in the wilderness if only because many people are constantly visiting it. But in any case, children can find out about the interrelationships of water, soil, animals, and plants. A park lake should be revisited to see how it changes from season to season. The following activities are suggested.



- a. Examine the water at the edge of the lake. It may be green, due to the presence of algae (tiny plants).
- b. Note any plants growing in the water. It may be possible to find pond lilies or other water plants.
- c. See how many birds can be identified on the water, flying over it, or bathing or feeding at its edges.
- d. Look for gulls, kingfishers, swallows, and other birds. Note what they eat and how they get the food.
- e. Watch mallard ducks on the lake. They may be getting food by scooping mosquito larvae from the surface, ducking for plants on the bottom, or picking up food thrown in by people. Distinguish between the brightly colored male and the drab female.
- f. Look for insects on, above, or just below the surface of the water. You may see dragonflies (Darning Needles) darting and hovering. They feed on other insects such as mosquitoes. Water striders or water boatmen may be observed in the pond. Notice how each of the insects moves.
- g. Note the kinds and sizes of fish there. Where did they come from?
- h. Examine the trees and other plants around the lake, Notice that some kinds grow where the earth is constantly wet; others grow on higher, drier ground.
- i. Look at any seeds floating on the lake. Water currents carry some kinds of seeds from one place to another, thus distributing them.
- j. Are there any amphibians present? The children may see tadpoles; they may see or hear frogs.
- k. Notice any litter in the lake. Develop the idea that litter detracts from the beauty of the spot and adds impurities to the water.
- l. Try to trace the source of the water. It may be piped in; it may be a spring or stream; or it may be rainwater draining in from surrounding hills. In the latter case, point out that these surrounding hills constitute a watershed.
- m. Scoop up some of the water and take it back to the classroom in a jar. Leave it uncovered in a sunny place in the classroom. Examine

the algae which may grow in it; note soil that settles to the bottom. Examine the water with a magnifying glass to see if you can find tiny water animals which may live in the pond. Examine the water under a microscope.

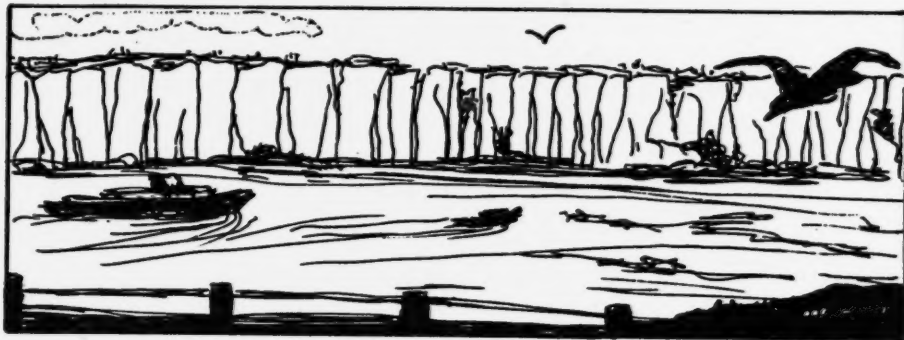
- *Many plants and animals find suitable living conditions in or near a lake.*
- *Tiny plants and animals live in lake water.*
- *Birds find plant and animal food in lakes.*
- *Some trees grow in moist soil, some in dry soil.*
- *Life in the pond changes from season to season.*

2. How does a river or stream change the land near it?

Somewhere near your school there may be a river or a stream which can show the ways in which water changes the surface of the earth. What effect does fast-moving water have on the land over which it flows? What does it do to the unprotected soil along the banks? What happens to very large, heavy rocks in the path of this flowing water? What effect does the speed of the rushing water have on what it carries along?

As the water loses its speed, what happens to the various things it has been carrying along? Stones stop rolling and heavy particles drop to the bottom. Silt and mud may settle in quiet water. Bars form in places where the current is checked. Sometimes a high bar forms when the stream is flooding. It may be above the normal level when the water returns to its usual height. Consequently the stream must cut a new channel around it if it is to continue running down to the sea. Streams where this happens repeatedly may wind back and forth so much that they are said to *meander*.

The following observations will help the children understand how rivers and streams change the surface of the earth.



- a. Gauge the depth of a shallow river or stream by dropping a weighted string to the bottom. Be sure the string is weighted heavily enough so that it goes down vertically. Measure the length of the wet part of the string.
- b. Measure the speed of the river. Station a child on the bank; have another child walk 100 feet upstream and toss in a stick. How long does it take for the stick to drift as far as the first child? Using the distance travelled by the stick and the time taken, compute the rate at which the water is moving. Compare the speed of the middle of the stream with the speed near the banks.
- c. Estimate the depth to which this stream has cut into the surface of the earth. This can be done by finding the distance between the level of the river and the top of the valley walls, and adding the depth of the water.
- d. Examine the river to note signs of erosion. See if exposed soil is being washed away by the current. Have rocks been placed on the banks to slow up the cutting action of the water? Are plants helping to protect the soil? Look for places where rainwater running down hills has cut *gullies*, (miniature valleys) into the banks.
- e. Look for bridges that may span the river. Estimate how high they are above the level of the water. Note that they must be above the level of a possible spring flood.
- f. Listen for the sounds made by the water as it meets various obstacles, lapping against the banks, splashing past rocks, tumbling over the drop at a fall, quiet in the places where pools are formed.
- g. Find places where silt and debris such as driftwood, discarded paper, and parts of plants have been deposited. Note how this deposited material changes the landscape and how it may influence the course of the current.
- h. Note the appearance of the water. Is it clear or muddy? Fill a jar with some of the water and take it back to the classroom. Let it stand undisturbed for a few days, then look for any soil that may have settled to the bottom. This is soil that has been washed from the land. If possible, collect one sample of the water when the river is low, and another when the river is flooding. Compare the deposits in the bottoms of the two jars.
- i. Is there evidence that waste has been dumped in the stream?
 - *A stream can move earth, stones and other materials.*
 - *A stream can change the shape of its banks.*
 - *The faster a stream moves, the more material it can carry.*



3. What can we see in New York Harbor?

A harbor is unique in the possibilities it offers for developing understandings about natural forces and the changes man makes in his environment. Following are some activities which can be carried on there.

- a. Take the class to a point from which a large section of the harbor can be observed. If possible, take with you a government chart of the harbor. Obtain a chart from the *U.S. Geodetic Survey*, Washington, D.C. Locate the shores and islands on the chart; note the depth of the water, and point out the channel by which the early settlers first sailed up from the sea. Note how the land juts out in some places, making protected anchorages; how the lower tip of Manhattan offered a convenient and reasonably safe place for the newcomers to live. A class trip on a ferry boat would be helpful.
- b. Choose a distinctive spot on a piling or embankment and, by observing it for a while, note whether the tide is rising or falling. In what other ways can this be determined?
- c. Locate buoys that mark the channel today and watch boats that may be entering or leaving the harbor.
- d. Look for the dredges that work year round, keeping the channel deep enough for the ships. (They may be too far out to see.) Dredging New York Harbor costs us over \$2,000,000 a year; but without this dredging, silt deposited by the Hudson River would clog the channel.
- e. Watch for gulls. Note how they search the surface of the water for refuse which they eat. They help to keep our harbor clean.
- f. Look at the piers built along the shores to berth the ships and facilitate loading and unloading.
- g. Look for barnacles on piers and rock embankments. Find out how they live and why they are a problem.
- h. Look along the shore for signs of erosion; note the embankments that have been built to protect the shore.

- *Soil constantly settles on the bottom of New York harbor.*
- *Our harbor must be dredged so that large ships can enter it.*
- *Living things are able to survive in or near the harbor.*
- *The depth of the water in a harbor limits the size of the ships that can use it.*

4. What goes on at an ocean beach?

An ocean beach can be used as a place to observe changes constantly taking place in the earth. On the beach, children can appreciate the effect of water and wind on sand. They learn that some plants and animals can live on a sand beach. Following are activities in which a class can engage.

- Let the children make their footprints in both dry and damp sand; later observe how these footprints are changed as the sand is dried by the sun and air, blown by the wind, or washed by the water. Notice footprints left by other people or by animals, if there are any prints which have not been obliterated by water, wind, or raking.
- Examine the "white" sand. What is sand made of? (Sand is mainly broken-down rock.) Use a hand lens to observe that the grains are not all the same color. The dark red grains may be garnet. The clear grains are quartz. The black grains may be any number of minerals, depending on the type of rock from which the sand originated. A common black, flaky mineral is mica.
- Dig a hole in dry sand, away from the water. Try to keep it full of water. What is it about sand that makes this impossible to do?
- Look for ripple marks. They are little ridges made by wind, waves, or currents moving over the sand. The ridges vary in height and width, depending on the speed of the wind, waves, or currents, and the dampness of the sand. They look somewhat like ripples of water.
- Have the children determine, by using a streamer held aloft or by observe a flag, whether there is a land breeze or a sea breeze blowing. (The breeze is named for the direction *from* which it comes.)



GRADE FOUR

- f. Notice that the beach slopes down to the water. Generally, the more gradual the slope, the wider the beach.
- g. How does the color of the sand near the water indicate the direction of the tide? If the sand is dry beyond the farthest advance of the waves, it is an indication that the tide is coming in. If the sand beyond the farthest advance of the waves is wetter (darker) than the rest of the sand, the tide is going out.
- h. Examine the jetties, built at 100-yard intervals in some places to halt the movement of the sand, which is constantly shifting from east to west on most New York City beaches. It can be seen plainly that the sand on the east side of each jetty is higher than that on the west side. In some instances, rocks may have been set against a wooden jetty to give added strength. Rockweed may be growing on these rocks.
- i. Look for sand dunes, where the beach has not been levelled for buildings or other purposes. These dunes have been formed when the wind, blowing across the beach, picks up and carries sand and then deposits it when the force of the wind is broken. Thus one side of a dune is often steeper than the other. Sand may be blown from one place to another, burying houses and trees. Find the beach grass (*Amophillia*) that may have been planted on a dune in an effort to prevent the wind from blowing the sand away. Look for snow fences which may have been put up to catch sand and start dunes.
- j. Listen to the crashing of the breakers. Have children describe what they hear. As they are listening, have the children tell if they can feel the sand shake underfoot when the waves crash.
- k. Point out to the children that the *tide* is not just a wave coming ashore, but is a rise or drop in the level of the water.
- l. Examine the debris which is cast on the shore by the waves. Notice that it is composed of many kinds of things: large and small pieces of driftwood; logs; parts of plants, including various species of seaweed; perhaps a variety of shells; the remains of sand crabs.
- m. Allow the children to pick up and examine any shells which have been strewn on the beach from the water's edge to the line of the highest tide. Many of the shells will have been broken by the surf, but many whole specimens can be found. Point out to the children that these shells once housed live animals. Occasionally one finds live specimens on the beach. Such animals cannot survive under these conditions. They soon die when dropped there by birds or waves.
- n. Look for, and try to identify, any of the forms of plant or animal life that may have been cast up on the beach, such as "sand collars" (the

egg cases of the moon snail), "mermaid's purse" (the egg case of the skate), horseshoe crabs, starfish, dead fish, sea lettuce (like a sheet of green cellophane), or rockweed (brown and with air bladders the children like to snap).

- o. Look for whitecaps on the waves. Air was trapped in the water as it moved, making the water appear white.
- p. Examine wood and metal cast ashore, or on buildings near the beach, to find evidences of erosion caused by wind, water, or salt deposited by spray.
- q. Scan the horizon; watch for smoke coming from ships.
- r. Smell and try to describe the air of a sea breeze.
- s. Have the children observe the salt which may have been deposited on their arms by spray from the ocean. The water along many of our beaches may be polluted by sewage, so the children should be warned against tasting or swallowing it.
- t. Look for bird tracks in the sand and watch birds feeding. Gulls are scavengers. They pick up debris from the sand or water. Terns dive for small fish. Sandpipers are smaller birds which follow the receding waves to probe for small animals in the wet sand.
- u. Have the children notice the color of the ocean and describe it. The color varies with the depth of the water and other factors, and changes with the shifting light. Fill a glass with ocean water. What color is it?
- v. Notice how the white sand reflects the light. Sometimes the light is so strong that we protect our eyes from it with dark glasses. On prolonged field trips, it may also be necessary to protect the skin from sunburn or windburn.
 - *A beach is an ever-changing place.*
 - *Wind and water change the appearance of a beach.*
 - *Many plants and animals live near the edge of the ocean.*
 - *We try to protect a beach from being worn away.*
 - *Only a few plants can live in sand.*

EVALUATIVE ACTIVITIES

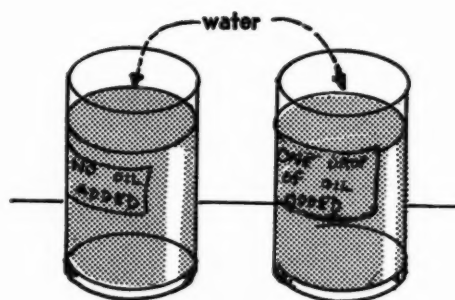
Note: No evaluative activities are listed here because they are included in the many detailed experiences provided in the preceding materials.

C. MORE TO FIND OUT ABOUT WATER

As children become aware of the importance of water, they may wish to find out more about special phases of this natural resource.

Children should have very little difficulty in obtaining information about water. Encyclopedias, textbooks and other books, as well as magazines, contain a great deal of material for class discussion and experimentation. From the following list children may select many worthwhile research activities.

1. How did the Indians get their drinking water?
2. "Water from a moving stream is fit to drink." Why is this a poor rule to follow when camping?
3. Find the pipe in your basement through which the water enters the house.



Does oil prevent evaporation?

4. In some reservoirs a thin film of a special harmless oil is spread over the water. This prevents fast evaporation. To demonstrate this, pour the same amount of water into each of two glasses. In only one glass place a drop of any light oil. Label both glasses. Keep records of the level of the water in each glass.

5. Why doesn't the drinking water in the pipes under the streets freeze in the wintertime?
6. What is the difference between an ordinary well and an artesian well?
7. Why does spring water seem so cool in the summer?
8. What is meant by a *water table*? How can a well run dry?
9. Engineers are talking about getting drinking water from the ocean. How is this possible?
10. What is meant by *water pollution*?
11. Bring in an old faucet. Show how a washer works and how to change a bad one.
12. Evaporate drinking water. Evaporate salt water. What materials remain?
13. In which months do our watersheds get the most rain? Use almanacs.

14. If possible, bring in a water bill to show how some home owners pay for their water.
15. Why is water needed by all living things?
16. Trace the sewage pipes in the home and in school.
17. How are caves formed? What are stalactites and stalagmites?
18. What causes waterfalls?
19. How does a breakwater protect beaches?

BASIC SUPPLY LIST FOR THE WATER WE USE

*Indicates quantity for entire class; other quantities specified are for each group of 4 children.

E-1: Science Supply List

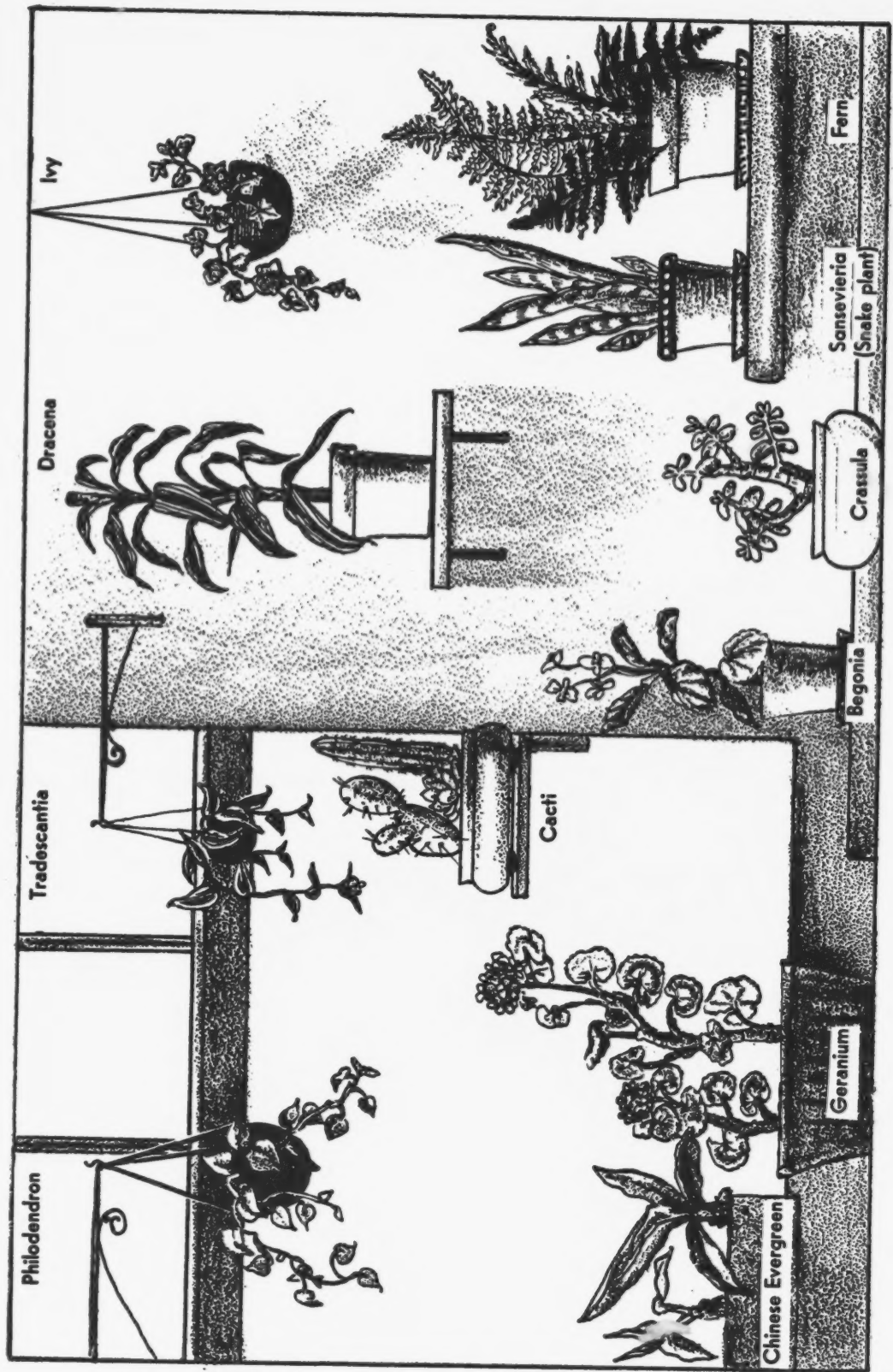
- | | |
|-----------------------------|----------------------|
| *1 bag of Soil | 1 Rubber Tubing, 12" |
| 1 large Flower Pot | *1 bag of Gravel |
| 1 Aquarium | *1 Microscope |
| 1 sheet Aluminum metal foil | |

G-1: General Supply List

- | | |
|--------------------------|-------------------------|
| 1 pkg. Modeling Clay | 1 Strainer |
| 1 plastic Drinking Glass | 1 paper Cup |
| 1 pkg. Plasticene | 1 Darning Needle |
| 1 Pencil | 2 Drinking Straws |
| *1 bag of Sand | *1 roll Cellophane Tape |

Miscellaneous

- | | |
|--|---------------------------------------|
| 1 small Sprinkling Can | 1 empty Milk Bottle |
| *1 tray of Ice Cubes | Assorted Twigs |
| *1 pan of "Snow" (from refrigerator freezer) | Assorted Leaves |
| 1 empty frozen Juice Can (opened at both ends) | Assorted small Stones |
| 1 empty Shoe Box | 1 Eyedropper |
| 3 empty Milk Cartons | *1 jar Pond Water (or Aquarium water) |



A "Green Thumb" in the Classroom

The classroom is home for about one half of the waking hours of teachers and students alike. It becomes more cheery and colorful with the addition of plants which can be cared for by the children. Teachers and children can acquire "green thumbs" by putting them in soil. If there are different kinds of plants in a room there will be opportunities to meet the problems presented by each. Children should be encouraged to observe the plants, report on their growth and try to find the best ways of caring for each kind.

The hardy plants used most often in the classroom are: geranium, ever-blooming begonia, coleus, tradescantia, philodendron, pothos, English ivy, grape ivy, crassula, ferns, cactus, snake plant, nephthytis, Chinese evergreen, dracaena, pick-a-back, peperomia.

Children can also grow sweet potatoes, beet and carrot tops, seeds of avocados, squash, watermelons, pumpkins, grapefruit, lemons, oranges, apples, peaches, cherries, lima beans, and sunflowers. See illustration on page 201.

Bulb growing, of course, is a well-established custom in schools. See illustration on page 184 in *Science; Grades K-2*.

In the spring, marigold, nasturtium, or petunia seeds will produce attractive and hardy plants which can be grown in school.

Covered terraria can be made with gravel and soil in a fish tank or bowl or a large mustard jar obtained from the neighborhood delicatessen. See illustration on page 66.

Plants will grow successfully if the following are provided:

Sufficient water. Plants should be watered only when the soil feels dry. However, when adding water soak the soil thoroughly.

Good drainage. The pot or box should have holes in the bottom to allow excess water to escape. (The roots of a plant require air. Water which remains may prevent air from entering the soil.) Saucers or aluminum pie plates under flower pots will protect the woodwork and catch drained water. One can water plants by adding water to the saucer until the top of the soil is moist. (Empty the saucer of any water which remains after the soil is moist.)

Suitable temperature. Plants should not be placed on hot radiators or in hot or cold drafts. Protect plants over cold weekends.

Proper light conditions. Experience is the best teacher. A geranium, for example, needs a good deal of sunlight. Cactus also thrives in sunlight. Begonias and some ferns, on the other hand, should not be kept in direct sunlight for many hours at a time. Most plants will grow well with only a few hours of sunlight. Many will need only the light from the sky. No green plant, however, will do well in a dark area.

Good Soil. While each plant has its own soil requirements, any good garden or potting soil will usually be satisfactory. The addition of sand will make the soil more porous. If the soil dries too quickly peat moss or humus can be added. Commercial fertilizer may be used, but only according to the directions on the package. *Note:* When transplanting, take care to avoid injuring the roots.

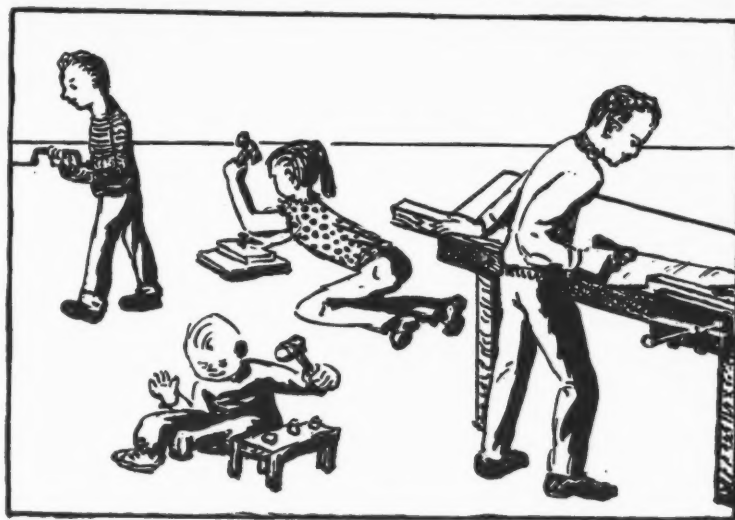
Other care. Leaves should be showered or washed with a sponge from time to time. Insect pests can be removed by washing or by using specific insecticides.

Children may interview someone in the school or neighborhood who has had notable success in growing plants and report to the class on the advice obtained. There are also good books on household plants in any library.

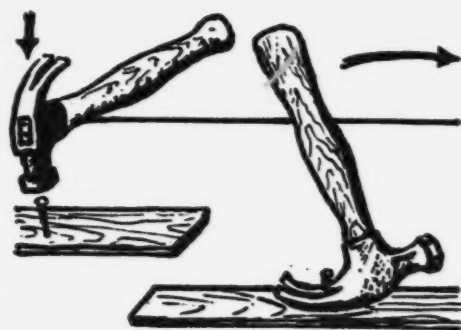
Tools We Use

In the course of constructing models and performing experiments in science, children use common tools such as hammers, screw drivers, pliers and saws. The teacher may use the opportunity that is thus presented for improving children's skill and understanding in the use of tools. The following supplementary material is intended to help children look more closely at tools, and to discover how they work and how to use them safely.

As they use tools for their own projects, children achieve a better appreciation of the role that tools play in everyday life. As they observe the tools more intently, they learn that tools are used because they give us greater force, greater speed, greater convenience or greater accuracy. The following activities, possible learnings and safety suggestions may be helpful in teaching about tools.



ACTIVITIES



HAMMERS. Children examine all kinds of hammers and mallets. They use the tools to hammer nails into wood and also to remove nails. They test the magnetized head on the upholsterer's hammer. They compare the weight of a heavy hammer with that of a lighter one.

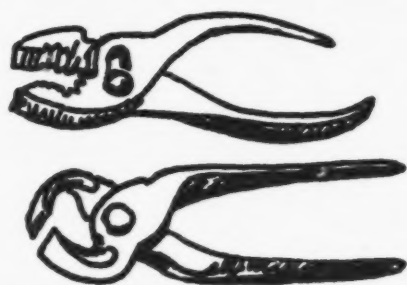
The children examine the handles on the hammers. They check to see how the handles are attached to the heads. They observe the materials used for hammer heads and handles and relate the materials used to the use of that tool.



SCREWDRIVERS. Children may bring in all kinds of screwdrivers and use them to drive screws into a soft piece of wood such as pine. (The teacher may have to drive in nails beforehand to make holes so that it is easier for the children to practice driving in the screws. Soap on the screw threads also makes it easier to drive the screws.)

Children may experiment with joining two pieces of wood which have matching pre-drilled holes. Use nuts and bolts for fastening. Also, children may practice using a screwdriver to tighten nuts and bolts on their mechanical building sets.

Children conduct a survey to see where wood screws, nuts and bolts are used in the classroom.



PLIERS. Children may bring an assortment of pliers from home and tell how the pliers are used. In class they use the pliers to pick up objects, hold things tight, tighten bolts, and snip wire. They become familiar with all kinds of pliers and relate the shape of the tool to its use.

SOME POSSIBLE LEARNINGS

1. There are many kinds of mallets and hammers.
2. Hammers are shaped for their jobs.
3. Some materials used in hammers are steel, wood, and rubber.
4. Handles are sometimes forced into the head of the hammer and kept there by wedges.
5. We can hit a nail hardest when we hold a hammer at the end of the handle.
6. We can pull a nail out with a claw hammer most easily when we hold the handle at its end.

1. Screwdrivers are made of many materials; most of them are steel with a wooden or plastic handle.
2. Screwdrivers are shaped differently to perform different jobs.
3. When we turn a screwdriver clockwise, we drive the screw or bolt in; when we turn it counterclockwise, we loosen the screw or bolt.
4. Most screws have points. They may be found holding pencil sharpeners, hinges, and window-shade pulleys to wood.
5. Bolts do not have points. They screw into metal nuts or threaded holes. They may be found on radiators, typewriters, switch plates, etc.

1. Pliers are used to do many different jobs: to pick up, grab, twist, cut.
2. When we close the handles of pliers, the jaws close also. When we open the handles the jaws open.
3. With pliers, we can hold things tighter than with our fingers alone.

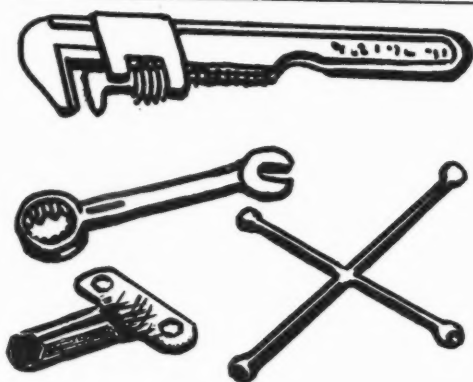
HOW TO USE THE TOOL SAFELY

1. Use the proper hammer for the job.
2. Use the hammer that is appropriate for your strength.
3. Do not use a hammer with a loose handle.
4. When nailing, hit gently at first, holding the hammer near the head with one hand, and holding the nail with the other hand until you get the nail started. Now take your hand away from the nail, hold the hammer closer to the end and continue nailing.

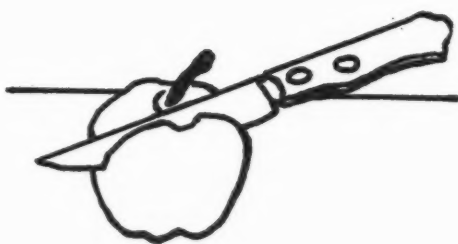
1. Use a screwdriver of the right length, with a head of the correct size to do a job.
2. Do not use a screwdriver as a pick, a chisel or a crowbar.

1. Be sure that the jaws of the pliers do not slip off your work, or you may pinch your fingers between the handles.
2. Do not hold wire with pliers until you are sure that the wire is not connected to a source of electricity.

ACTIVITIES

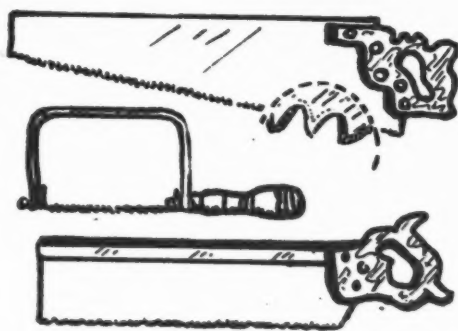


WRENCHES. Children tell where they have seen wrenches used. They learn to identify many kinds of wrenches and they associate the shape with its special use. Have the children use a wrench to tighten a large nut or a bolt, to hold two pieces of wood together (see section on screwdrivers).



KNIVES. Children discuss the various uses for knives and other tools with sharp edges. They list the jobs done with these tools. They discuss how a good workman takes care of his fine tools to protect their edges and to be safe. They see a sharpening stone and wheel and learn how they are used.

The teacher may use a kitchen knife to cut an apple, using both the blunt edge and the sharp edge. The children compare the effort used to do the job in each case.



SAWS. Children examine many kinds of handsaws: crosscut saws, rip saws, hacksaws, and coping saws. They examine the teeth with a magnifying lens and note the sharp cutting edges on the teeth. They also examine the blades and note that they vary in length and in the size and the shape of the teeth.

They use a coping saw to cut a thin piece of pine wood and they learn that the saw cuts best in one direction only. They compare the cutting action of a saw with the cutting action of a knife, and they consider the advantages of the saw. They compare a coping saw to a hacksaw in cutting aluminum or copper tubing.

SOME POSSIBLE LEARNINGS

1. Wrenches are used to tighten or loosen nuts, bolts, pipes, and some pieces of machinery.
2. Wrenches are made in many sizes. Some wrenches are adjustable.
3. When we use a wrench with a long handle, we are able to turn nuts tighter than when we use a short-handled wrench.

1. Knives have special shapes to do special jobs.
2. Knives should be kept in a safe place.
3. When a knife is sharpened, the rough stone rubs off pieces of metal from the blade to bring it to a sharp edge.
4. When a knife is sharpened on a grinding wheel we sometimes see sparks, and the knife gets hot.

1. A saw has tiny teeth with sharp edges which cut wood or metal when the saw is moved.
2. The tiny teeth work best when the saw cuts the wood in one direction only.
3. Different saws do different jobs. Some saws cut wood, others cut metal. Some saws cut in straight lines, others are better for cutting curves.
4. Sometimes the blade of a saw becomes hot when in use.

HOW TO USE THE TOOL SAFELY

1. Use the proper wrench for the job.
2. Use the right-sized wrench, or it may slip when you turn it.
3. When using a wrench to tighten a nut on a bolt, do not turn it too hard, as you may strip the threads.

1. When you cut with a knife, watch your fingers and cut away from you.
2. Do not keep open knives or other sharp objects in your pockets.
3. Do not use knives or other sharp instruments as toys.
4. Do not use knives as screwdrivers or for prying.

1. Hold your work firmly when sawing.
2. Keep your fingers out of the way of your saw.
3. Store your saws carefully.
4. Use the proper saw for the job.

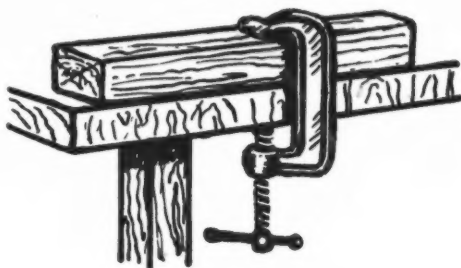
ACTIVITIES



FILES, SANDPAPER. Children examine all kinds of files. They see the teeth on coarse files and use a magnifying glass to examine the teeth on fine files. They feel coarse and fine sandpaper and dip the paper into water to loosen the sand particles. Children bring in nail files and sandpaper and use them to file various materials.



SCISSORS AND SHEARS. Children examine scissors and shears. They observe how the motion of the handles affects the motion of the blades. Ask children for what purposes they would use scissors and shears. Experiment by attempting to cut sheet metal with an old pair of scissors, and then with shears. Have children relate the shape and the size of the tools to their uses.



CLAMPS AND VISES. Children may bring small clamps, vises, clamp-on lamps, and other devices to school. They also recall where these tools are used at home and in the neighborhood.

A small clamp can be used to hold two rulers securely against each other. Children then try to separate the two rulers and find that it is difficult to do so.

Hold a ruler in a clamp or vise and ask the children to remove the ruler. Compare the effort needed to remove the ruler when the vise is tight with the effort needed when the vise is not very tight.

SOME POSSIBLE LEARNINGS

1. A file has teeth with fine edges which cut into wood and metal when the file is moved across the material.
 2. Different files are used for different jobs.
 3. A file works best when moved in one direction only.
 4. The particles of sand on sandpaper act in the same way as teeth on a file.
-

1. Scissors and shears are used to cut various materials.
 2. Scissors usually have proportionately longer blades and shorter handles than metal shears.
-

1. The jaws of clamps and vises are tightened when a screw on the tool is tightened.
2. A long handle makes it easy to turn the screw on a vise.
3. The tighter the screw is turned in the vise, the tighter the jaws close.

HOW TO USE THE TOOL SAFELY

1. Use a handle on the tang (pointed end) when using a file.
 2. Do not use a file for prying things, since files are brittle and may crack.
-

1. Always offer the handles of scissors when giving them to someone.
 2. Do not put scissors in your pockets.
 3. Do not use scissors for prying since the blade may snap off.
 4. Do not run with scissors in your hands.
-

1. A tight clamp can make a mark in soft wood.
2. Do not hammer on the jaws of a vise.

Films and Filmstrips

This list of sound film and filmstrip resources has been prepared to implement the teaching of *Science: 3-4*.

All listed films and filmstrips have been approved by the Board of Education. Annotations are based on evaluations by committees which have carefully screened the films and filmstrips for city-wide use. Grade placement and utilization in individual schools should be based on local previewing and adaptation to specific needs. Recommended filmstrips must be purchased by individual schools since they are not available on loan. Board of Education order numbers follow some annotations.

All films are sound motion pictures, 16 mm. width, and may be available on loan from the *Central Loan Collection* of the Bureau of Audio-Visual Instruction. Consult the Bureau's listings in *Instructional Films and Tapes* for borrowing procedures. Many of the films listed are also available at the local film centers. Schools should consult film center lists and direct their requests to these centers before requesting service from the *Central Loan Collection*.

For approaches to the use of films and filmstrips, see *Audio-Visual Materials In The Science Program*, on pages 15-16.

Magnetism and Electricity

FILMS: GRADE 3



- | | | |
|---|---------|-------------|
| ELECTRICITY ALL ABOUT US | 11 min. | Coronet |
| Illustrates the characteristics of static electricity, and electrical circuit, and the ways electricity is generated: 18.51 | | |
| ELECTRICITY: HOW TO MAKE A CIRCUIT | 11 min. | E.B.F. |
| Shows what a circuit is; indicates the differences between high and low voltage; and illustrates the construction of a dry cell. | | |
| FLOW OF ELECTRICITY | 12 min. | McGraw-Hill |
| Explanation of the lighting of a bulb by using a dry cell. A simple circuit is demonstrated and the role of the switch is explained. | | |
| THIS IS ELECTRICITY | 11 min. | Cenco |
| A father explains basic principles of electricity to his daughter. Included in the film are dry cells, conductors, insulators, circuits, switches and generators. | | |

FILMS: GRADE 4

THE COMPASS

11 min.

McGraw-Hill

Shows use of compass in practical situations.

MAPPING A TREASURE HUNT

12 min.

Cenco Educational Film

Develops primary directions and how they are used to draw a map. Elementary geographical concepts with a light story line.

SIMPLE DEMONSTRATION WITH MAGNETISM

Demonstration and experiments explain basic concepts of magnetism: magnets produce a force, have poles and can move other magnets. The concept of the earth as a magnet is introduced.

FILMSTRIPS: GRADE 3

CURRENT ELECTRICITY

Filmstrip House

A brief introduction to current electricity. Discusses sources of electricity, e.g., battery, generator; the uses of wires in conducting electricity; and the role of switches. 40451.1

ELECTRICITY

McGraw-Hill

Explains the factors which affect the flow of electricity through a simple circuit. 37020.11

HOW ELECTRICITY HELPS US

Filmstrip House

Presents uses of electricity in daily living: home lighting, traffic lights, power for household appliances and for transportation. 40451.11

FILMSTRIPS: GRADE 4

MAGNETISM AND ELECTRICITY

S.V.E.

Explain simple ideas in magnetism and electricity, such as polarity, strength of magnetism, compasses; discusses where electricity and magnetism are used in the home.

Earth in Space



FILMS: GRADE 3

SHADOWS ON OUR TURNING EARTH 11 min. Film Associates of California

Shadows are made when objects block light. The surface of the earth on the side away from the sun is always in shadow. The movement of the earth produces day and night.

WHAT MAKES DAY AND NIGHT

9 min.

McGraw-Hill

Story of day and night told simply. Concept of rotation. Day and night in different parts of the world.

FILMS: GRADE 4

THE MOON

14 min.

Cenco

Moon's orbit, phases, size and topography; the lunar month and the moon's effect on earth's tides are explained through animation.

THIS IS THE MOON

10 min.

McGraw-Hill

Explains the relation of the moon to the sun and earth; how the moon gets its light; the phases of the moon; and the moon's physical characteristics. 597.7

WHAT DO WE SEE IN THE SKY

Coronet

Freddy's curiosity about things he sees in the sky leads him to learn about the sun, moon, planets, stars and constellations.

WHAT IS AN ECLIPSE?

10½ min.

Film Associates of California

Demonstrates how the motion of the moon around the earth causes both solar and lunar eclipses.

FILMSTRIPS: GRADE 3**FINDING OUT ABOUT DAY AND NIGHT**

S.V.E.

Discusses why we have day and night, what causes moonlight, the changing shapes of the moon, simple concepts about the sun. Suggestions for follow-up and classroom experiences. 36483.31

FILMSTRIPS: GRADE 4**THE MOON**

E.B.F.

Explains the physical characteristics of the moon, the phases of the moon, the meaning of month and some ancient myths about the moon. 36830.12

THE MOON

Filmstrip House

Describes the formation of the moon, its environment and physical characteristics. Offers problems to be solved by pupils. 39055.1

MOON, SUN AND STARS

S.V.E.

Explains some simple concepts about the sun, the moon and the stars. 38590.13

OUR MOON

Filmstrip House

Depicts the different phases of the moon with suggestions as to what one might observe if he were standing on the moon. 40450.52

OUR SILVERY MOON

Illustrates scientific information about the moon. Depicts its physical features.

Living Things**FILMS: GRADE 3****A CLOSE LOOK AT DESERT ANIMALS** 11 min.

Sigma Ed. Films

Close-up photography reveals adaptations of desert animals.

ADELIE PENGUINS OF THE ANTARCTIC 23 min.

Sterling Ed. Films

Life cycle of Adelie Penguin showing adaptation to cold climate.

ADAPTING TO CHANGES IN NATURE 10 min.

Journal Films

Shows ways in which different animals and plants survive in the changing natural world.

ADVENTURES OF A CHIPMUNK FAMILY	10 min.	E.B.F.
Training of chipmunk babies during early summer.		
ANIMAL TOWN OF THE PRAIRIE	10 min.	E.B.F.
How prairie dogs reshape their environments to suit their own needs.		
ANIMALS AND THEIR HOMES	10 min.	McGraw-Hill
Functions of animal homes and how they are built.		
ANIMALS AT NIGHT	11 min.	E.B.F.
How nocturnal animals differ from animals which are active during the day.		
ANIMALS THROUGH THE WINTER	10 min.	McGraw-Hill
About hibernation, migration, food storage, heavy fur coats.		
ANIMALS PROTECT THEMSELVES	10 min.	Coronet
A boy discovers ways animals protect themselves from enemies.		
ANIMALS THAT FLY	10 min.	Film Assoc.
How insects, birds and bats fly.		
BIOGRAPHY OF A BEE	10 min.	Moody Institute
Observing development of a bee from egg to adult.		
BIRDS AND THEIR BABIES	10 min.	A.V.-E.D.
Remarkable films of baby birds and their needs.		
BIRDS ARE INTERESTING	11 min.	E.B.F.
How birds differ in structure and in food-getting.		
FALL BRINGS CHANGES	11 min.	Churchill-Wexler
Adaptations of plants and animals.		
THE FRESH WATER POND	13 min.	E.B.F.
Shows interdependence of plants and animals in a pond.		
LET'S WATCH PLANTS GROW	11 min.	Coronet
Carefully planned experiments to show plants need water, minerals and sunlight.		
NATURE'S HALF ACRE	33 min.	Walt Disney
Excellent film showing ever-present fight survival.		

FILMS: GRADE 4

FROM SEED TO GRAIN	9 min.	McGraw-Hill
Time lapse photography showing planting of seed in plowed soil to final harvest.		
FROM SEEDS TO PLANTS	10 min.	Gateway Prod.
How beans and corn seeds grow.		
GARDEN PLANTS AND HOW THEY GROW	11 min.	Coronet
Plants which store food in their stems, leaves, roots and seed pods. Compares poor and rich soil. Some destructive insects and some which help plants.		
HOW SEEDS ARE SCATTERED	10 min.	McGraw-Hill
How animals, wind, water, and people help spread seeds.		

HOW TO GROW RADISHES	6 min.	Tabletopper Prod.
Time lapse photography helps describe how radish seeds grow.		
LEARNING ABOUT LEAVES	10 min.	E.B.F.
Function, kinds, shapes. Suggestions for collecting and mounting.		
LEARNING ABOUT SEEDS	11 min.	E.B.F.
Time lapse photography shows how seeds grow and are dispersed.		
PLANTS THAT GROW FROM LEAVES, STEMS AND ROOTS	11 min.	Coronet
Excellent time-lapse photography.		

FILMSTRIPS: GRADE 3

PLANTS CHANGE THROUGH THE YEAR	
Effects of changing seasons on plant world.	
ANIMALS ADAPT TO WINTER	
Adaptation of animals such as rabbits, squirrels, birds. Explains hibernation, migration, and growing of heavy coats.	
GREEN THUMB IN THE CLASSROOM	McGraw-Hill
Requirements needed for growing plants.	
COOPERATION AMONG PLANTS AND ANIMALS	
Protecting plants and animals: Hunting laws, fishing seasons, wild life preserves, laws protecting wild flowers, pest control.	

FILMSTRIPS: GRADE 4

SOME WAYS SEEDS ARE SPREAD	
Illustrates the different ways dandelions and other flower seeds are spread; also ash, maple and other tree seeds.	
FLOWERS AND FRUITS	International Film Bureau
Function of flowers. How seeds grow.	
GROWING NEW PLANTS	
How new plants can be produced by seeds, runners, grafting and other means.	
PLANTS AND SEEDS TRAVEL	Eyegate
Explains how seeds travel by land, water, and air.	
SEEDS	
Parts of seeds. How different seeds grow. How they are dispersed.	
SOIL IS FOR GROWING	McGraw-Hill
Composition of soil and how it is formed. Simple experiments are included.	
GROWING NEW PLANTS	
Grafting, budding, transplanting, seeding.	

Sound and Light in Communication



FILMS: GRADES 3 and 4

HOW SOUND HELPS US	11 min.	Coronet
Basic qualities of sound. Sounds are made by blowing, plucking, and hitting things together.		
LEARNING ABOUT SOUND	10 min.	E.B.F.
Discusses vibration, conduction, high and low tones. How the ear functions.		
SOUND AND HOW IT TRAVELS	10 min.	E.B.F.
Defines sound, vibration. How sounds differ.		
SOUND FOR BEGINNERS	10 min.	Coronet
Slow motion photography and demonstrations show types of vibrations. How sounds travel through different substances.		
SOUND	10 min.	Gateway
How sound waves are made and carried. How the ear functions.		
SOUNDS ALL ABOUT US	10 min.	Coronet
Vibrations and pitch. Simple experiments.		
WHAT IS SOUND?	10 min.	McGraw-Hill
Nature, source and transmission of sound. 659.71		

FILMSTRIPS: GRADE 3

COMMUNICATION KNITS OUR WORLD TOGETHER	Eyegate
Explains how communication has made our world smaller. We communicate by speech, letters, signs, signals, telephone, telegraph, books, newspapers and magazines.	
OUR SENSES — HEARING	Eyegate
Explains parts of the ear and how it functions. How sounds are made and travel. Care of the ear.	
SOUNDS WE HEAR	Ives
How sounds are produced. How animals and humans communicate.	

FILMSTRIPS: GRADE 4

INVENTIONS THAT HELPED COMMUNICATION	Eyegate
Explains how voices of today can be recorded on records, tape or wire. It discusses phonographs, tape recorders, telegraphs and teletypewriters.	
MESSAGES TRAVEL AND ARE RECORDED	Eyegate
History of recording messages, including magnetic recording and pressed records.	

Weather



FILMS: GRADES 3 and 4

BE YOUR OWN WEATHERMAN	13 min.	Cenco
How to construct simple weather instruments and how to keep simple records and predict weather. 46.7		
HOW SUNSHINE HELPS US	11 min.	Coronet
How sunshine gives warmth and light; helps rain to fall and green plants to grow. 295.25		
HOW WEATHER IS FORECAST	11 min.	Coronet
Actual operation of a weather station.		
INSIDE THE WEATHER	13 min.	United World
Weather forecasting and its problems.		
LET'S LEARN TO PREDICT THE WEATHER	11 min.	Coronet
Basic weather facts, significance of wind direction, barometer reading, cloud formation.		
MEASURING TEMPERATURE	11 min.	McGraw-Hill
Experiments showing expansion and contraction of liquids. Kinds of thermometers and their use.		
RAIN	10 min.	Int. Film Bureau
Origin and composition of rain and clouds.		
SNOWFLAKES	11 min.	Moody
Depicts uses of snow; recreation; for irrigation. 551.1		
WATER IN THE AIR	12 min.	Cenco
Formation of clouds, fog, rain, snow, sleet, hail, dew and frost.		
WEATHER FOR BEGINNERS	11 min.	Coronet
Demonstrations to show why clouds form; rain; winds.		
SEASONS OF THE YEAR	11 min.	Coronet
How seasons are caused. Activities of animals, plants and people through various seasons and different weather conditions.		
SPRING COMES AGAIN	10 min.	Bailey Films
Characteristics of seasons; combines nature photography and poetic prose.		
WHY SEASONS CHANGE	11 min.	E.B.F.
Explains seasonal weather and length of days.		

FILMSTRIPS: GRADE 3

AIR AROUND US	S.V.E.
Cloud formation, relation of clouds to weather.	
A TRIP TO THE WEATHER STATION	
Professional instruments in use by weatherman.	

HOW A THERMOMETER WORKS

Filmstrip House

Shows different kinds of thermometer and how they are used in everyday situations.

A VISIT TO A WEATHER STATION

Eyegate

Effect of weather on everyday activities. Visit to a weather station to see weather vane, thermometer, anemometer, rain gauge, barometer.

WONDERS OF SNOW

Moody

Beauty of snow; its uses for recreation and source of water power for hydro-electricity.

FILMSTRIPS: GRADE 4

THE FOUR SEASONS

Eyegate

How seasons affect plants and animals.

Motion and Force in Transportation



FILMS: GRADE 3

FRICTION

Gateway

Simple demonstrations showing how friction is developed and reduced. Advantages and disadvantages of friction are shown.

FRICTION

McGraw-Hill

Poses the question of what friction is, and reviews factors which determine amount of friction.

FRICTION ALL AROUND

8 min.

McGraw-Hill

Introduces student to the importance of friction in creating heat, in wearing out many things, and in slowing down motion.

MOVING THINGS ON LAND

11 min.

Churchill-Wexler

Various ways people have devised to reduce friction are amusingly shown. Friction's usefulness is dramatized by excursion into startling world where it does not exist.

FILMS: GRADE 4

HOW MACHINES AND TOOLS HELP US

14 min.

Coronet

Levers, wheels, and inclined planes as simple machines, and their uses in constructing a house are shown.

HOW SIMPLE MACHINES MAKE WORK EASIER

11 min.

Coronet

A seesaw and slanted board lead beginners in science to understand what a simple machine is and how it helps us do work.

LET'S LOOK AT LEVERS

10 min.

Journal Films

Student is shown how levers help perform work beyond the strength of man. How levers help us lift, pry, move, hold, pinch, cut, weigh, and measure.

SIMPLE MACHINES

11 min.

E.B.F.

Explains principle of inclined plane; describes other members of inclined plane family—the wedge and screw.

YOU AND MACHINES

13½ min.

United World Films

Elementary treatment of simple machines in everyday life.

FILMSTRIPS: GRADE 3

FORCE CALLED GRAVITY

McGraw-Hill

Shows which way is up; what goes up comes down; how gravity affects tides; practical uses of gravity; overcoming gravity. 37905.32

FRICTION AT WORK

McGraw-Hill

Explains causes and effects of friction. Shows how man utilizes force of friction and how he overcomes it through the use of smooth surfaces, bearings, and oil. 37023.11

GRAVITY

McGraw-Hill

Gives examples of force of gravity. Shows how man uses this force and how he overcomes it. 37023.1

INTRODUCING THE WHEEL

Curriculum Materials Corp.

The history of the wheel, and illustrations of how the wheel helps make work easier; lifting, pushing and pulling. 37830.

FILMSTRIPS: GRADE 4

SCIENCE AT WORK SERIES: MACHINES (C)

E.B.F.

Describes six basic machines and their application to tools and mechanical devices. 2129.5

SIMPLE MACHINES

McGraw-Hill

Demonstration of simple machines, their uses and advantages, combinations of simple machines, importance in modern life. 39440.1

TOYS AT WORK

Ives

Presents relationship between simple machines; principles involved in the study of inertia gravity and toys. 39936.12

Earth and its Resources



FILMS: GRADE 3

ROCKS IN OUR NEIGHBORHOOD

13 min.

McGraw-Hill

Shows the various kinds of rocks used for building purposes because of their weathering resistant properties, the ease with which they are worked, and their beauty.

UNDERSTANDING OUR EARTH

Coronet

A fieldtrip is used to illustrate and examine the three classes of rocks: igneous, sedimentary, and metamorphic. Suggestions are made for classroom activities.

FILMS: GRADE 4

A VISIT TO THE WATERWORKS

E.B.F.

A class visits the waterworks. Sources of water and treatment of water.

WATER FOR ALL LIVING THINGS

9 min.

Educational Horizons

Past and present methods of supplying water to people, plants, animals, and industry. Future plans for supplying ever increasing needs.

WATER FOR THE COMMUNITY

Coronet

Why communities need water; sources of drinking water; steps in purification; how water is distributed to homes. Why water must be conserved.

WATER, WATER, EVERYWHERE

Coronet

By means of many visual experiences familiar to children such as plants growing near water, an animal drinking water, rain puddles disappearing, basic principles concerning water conservation are developed.

WORKING WATER

Dowling Pictures

Shows how water from snow gathers in rivulets, brooks, and rivers which are dammed to form large lakes, and how this water is distributed to the surrounding area.

FILMSTRIPS: GRADE 3

WIND AND WAVES

S.V.E.

The effects of wind and water on soil and rock (building up, tearing down). 38600.15

WHAT IS A ROCK

Benefic

How the three types of rock, igneous, sedimentary, and metamorphic, are formed and used. 40315

FILMSTRIPS: GRADE 4

CONSERVING OUR SOIL AND WATER

The principles underlying conservation of soil and water.

THE DAY THE WATER STOPPED

Curr. Mat.

Reasons for the lack of an adequate water supply during the warmer months, and methods of alleviating the situation. 36765

HOW RIVERS ARE FORMED

McGraw-Hill

Shows how rivers are formed from rain and snow; how they flow downward from mountains to the sea; how they carry water for all living things along their course; how they are useful to man; what man does to rivers.

IMPORTANCE OF CONSERVATION

Eye Gate

Shows how leaves, trees, plants, and roots protect the soil. Explains that conservation is the wise use of soil.

OCEANS

McGraw-Hill

Discusses the relationship of the oceans to weather, navigation, transportation, food supply, and man's development.

THE PROBLEMS OF WATER

Curr. Mat.

Presents problems related to water: too much; too little; pollution; run-off; increased consumption. Also depicts water cycle. 38902

UNDERGROUND WATER

S.V.E.

Shows the effect of underground water and rocks and soil. Describes formation of artesian wells, underground lakes, and water table. 38600.13

WATER AND SOIL

Eye Gate

Water is shown to be everywhere. Its many uses are depicted. Construction and use of aqueducts and reservoirs is shown. Erosion and the formation of pebbles, sand, rounded stones, and cracked rock are shown.

Bibliography

The publications for children listed in this bibliography have been selected to:

- provide good reading in science for children
- convey the meaning and spirit of elementary science
- provide science content related to the course of study
- provide enriched material for children with special science interests
- suggest valuable classroom procedures, experiments and projects.

Most of the publications are on the current lists of the Board of Education of the City of New York: *Library Books For Elementary And Junior High Schools; List Of Textbooks Approved During The Years 1961 Through 1965 For Use By Day And Evening Elementary Schools And Junior High Schools, 1965-1966*. The numbers which follow the annotation refer to the item numbers given in either of these publications.

For approaches to the use of books, see *Science and The Reading Program* on pages 13-15.

Following the listing of children's books is a bibliography of professional books on the teaching of science in the elementary school.

BOOKS FOR CHILDREN

Magnetism and Electricity



BEELER, NELSON and BRANLEY, FRANKLYN M. *Experiments with Electricity*. New York: Thomas Y. Crowell Co., 1949. 145p.

Practical, safe experiments using simple, everyday materials help explain the "how" and "why" of electricity. Useful for science clubs and special projects. 65-19-000

BRANLEY, FRANKLYN M. and VAUGHAN, ELEANOR K. *Rusty Rings a Bell*. New York: Thomas Y. Crowell Co., 1957. 32p.

Story of a boy who discovers how to make a bell ring. 65-19-001

EPSTEIN, SAM and BERYL. *The First Book of Electricity*. New York: Franklin Watts, Inc., 1953. 69p.

What electricity is; how it is produced; how it is used in the home; explanations of meters, fuses, toasters, electric bulbs, sockets and switches. Large illustrations. Helpful for teacher. 65-19-005

PARKER, BERTHA M. and HOLLEY, CLIFFORD. *Magnets*. Evanston, Illinois: Row, Peterson, 1949. 36p.

What magnets do; how they work; how to care for them. Compasses, magnetic toys, electromagnets.

PINE, TILLIE S. and LEVINE, JOSEPH. *Electricity and How We Use It*. New York: McGraw-Hill, 1962. 48p.

Explores the exciting world of electricity; how electrons flow in a circuit; what electricity can do; safety rules concerning electricity.

———. *Magnets and How to Use Them*. New York: McGraw-Hill, 1958.

An easy to read book which explains what magnets are, how they work and what they are used for. Simple experiments. 65-20-001

ROSENFELD, SAM. *The Magic of Electricity*. New York: Lothrop, Lee and Shepard, Inc., 1963. 158p.

Experiments involve use of inexpensive and easily obtained materials. The reader learns how and why electricity works. Good also for the teacher. 65-19-013

SCHNEIDER, HERMAN and NINA. *Let's Look Inside Your House*. New York: William R. Scott, Inc., 1948. 39p.

How to make a bulb light; make a switch; find out about conductors; and other interesting things using electricity. 65-13-008

———. *Let's Look Under the City*. New York: W. R. Scott, 1954.

A basic book on community utilities, water, sewage, electricity, gas and telephone and how the home is linked by these utilities to the city. 66-28-008

SCHWARTZ, JULIUS. *I Know a Magic House*. New York: McGraw-Hill, 1956. 32p.

Primary book on the wonder of everyday happenings in the home. Contains parts on electricity. Large illustrations. 71-02-201

VALEN, E.G. *Magnet*. New York: The World Publishing Co., 1964. unpagged.

With the help of the brilliant photographs of actual experiments the reader can explore for himself the world of magnets and magnetism, including the compass. 65-20-003

WYLER, ROSE. *The First Book of Science Experiments*. New York: Franklin Watts, Inc., 1952. 69p.

Easy-to-understand directions for performing experiments with air, water, plants, electricity and magnetism, chemistry and light. 65-00-079

Earth in Space



ADLER, IRVING. *Time In Your Life*. New York: John Day Co., Inc., 1955. 127p.

In explaining time, author explores stars and planets, rocks and rivers; history and the calendar, clocks and watches. 65-05-002

ASIMOV, ISAAC. *The Clock We Live On*. New York: Abelard Shuman, 1965. 172p.

The relatively uniform motion of the earth is used as a device to measure time. Origins of day, week, month and year. Good for interested pupils and teacher.

BENDICK, JEANNE. *The First Book of Time*. New York: Franklin Watts, 1963. 70p.

Explains how time is related to motions of bodies in space. Describes devices for measuring time. 65-12-001

- BRADLEY, DUANE.** *Time For You.* J.B. Lippincott Co., 1960. 110p.
Accurate detailed description of time pieces from the shadow stick to atomic clocks. Also presents the development of the calendar. 65-12-002
- BRANLEY, FRANKLYN M.** *A Book of Astronauts for You.* New York: Thomas Y. Crowell, 1963. unpagged.
How astronauts are selected and trained. 66-36-014
- _____. *The Moon-Earth's Natural Satellite.* New York: Thomas Y. Crowell, 1960. 114p.
A detailed study for children who have a special interest in the moon. Deals with the moon's motions, the tides, eclipses, conditions on the moon.
- _____. *What the Moon is Like.* New York: Thomas Y. Crowell, 1963. unpagged.
Reader is "placed" on the moon, with help of illustrations and informative text. 71-12-058
- COOMBS, CHARLES.** *Project Apollo, Mission to the Moon.* New York: Wm. Morrow and Company, 1965. 96p.
A detailed study of plans for sending three astronauts to the moon and insuring their safe return. 66-36-077
- FREEMAN, MAE and IRA.** *The Sun, The Moon and the Stars.* New York: Random House, 1956. 83p.
Good introduction to astronomy in easy-to-read language. 65-05-016
- _____. *You Will Go to the Moon.* New York: Random House, 1959. unpagged.
Describes a trip to the moon in easy-to-read language; good summary of science concepts. 71-12-097
- FROMAN, ROBERT.** *Faster and Faster.* New York: The Viking Press, 1965. 42p.
A book about speed. A fascinating account of ascending scale of speeds in the universe from slow movement of glaciers to high speed of light waves. 65-14-009
- HYDE, MARGARET O.** *Off Into Space!* New York: McGraw-Hill, 1959. 63p.
An imaginary trip to the moon and some of the planets. Deals with many basic ideas related to space travel. 66-36-043
- MACGREGOR, ELLEN and PANTELL, DORA.** *Miss Pickerell on the Moon.* New York: McGraw-Hill, 1965. 142p.
Well-loved fictional character takes trip to moon to find a cure for her sick cow. Accurate science information is part of an imaginative adventure. 71-46-107
- POLGREEN, JOHN and CATHLEEN.** *The Earth in Space.* New York: Random House, 1963. 80p.
The reader stops at different points on an imaginary trip into space. He looks back towards the earth and its neighbors in space. He has a good time, gets a new orientation and learns a great deal. 65-05-035
- RECK, ALMA KETHOE.** *Clocks Tell the Time.* New York: Charles Scribners Sons, 1966. 48p.
Describes early timekeeping devices and mechanical clocks. 65-12-007
- ROCCA, ANGELO.** *The Moon.* New York: Duell, Sloan and Pearce, 1961. 58p.
Moves from ancient ideas about the moon to current findings. Diagrams and illustrations are useful. 65-05-039

SCHWARTZ, JULIUS. *The Earth Is Your Space Ship*. New York: McGraw-Hill, 1963. 32p.

Quietly captures the excitement of space travel. As the readers whirl through space with feet firmly on the earth they learn many space concepts. 65-29-022

SCHLEIN, MIRIAM. *It's About Time*. New York: Young Scott Books, 1955. unpagged. Poetic, interesting introduction to the idea that time never stops. 71-02-185

SCHNEIDER, HERMAN and NINA. *How Big Is Big?* New York: Wm. R. Scott, Inc., 1950. 48p.

With striking illustrations, the authors help the child understand how he fits into scheme of the universe, using size as the basis. 71-02-197

———. *You Among the Stars*. New York: Wm. R. Scott, Inc., 1951. 60p.

Magnificent illustrations and poetic text make this an excellent first book of astronomy, simplifying vast concepts and giving the child a feeling of his place in the universe. 65-05-044

SHAPP, MARTHA and CHARLES. *Let's Find Out About the Moon*. New York: Watts, 1965. 55p.

Facts about the moon, with graphic comparisons of the size of the moon and its distance from the earth. What astronauts will need when they reach the moon. 71-12-374

———. *Let's Find Out What's Big and What's Small*. New York: Franklin Watts, Inc. 1959. unpagged.

Children learn in non-numerical terms that size is a matter of comparison. A vocabulary list of repeated words appear on the last page. 71-12-303

SEVREY, IRENE O. *The First Book of the Earth*. New York: Franklin Watts, 1958. 63p.

The formation of the earth, its rivers, mountains and volcanoes and its relationship to the sun, moon and stars. 65-29-023

SONNENBORN, RUTH A. *The Question and Answer Book of Space*. New York: Random House, 1965. 32p.

Good book for browsing or answers to specific questions about space.

TRESSELT, ALVIN. *How Far is Far?* New York: Parents' Magazine Press, 1964. unpagged.

A boy learns how relative everything is by asking questions like: How far is far? How high is up? How big is big? Good illustrations. Simple text.

WOLFE, LOUIS. *Let's Go To a Planetarium*. New York: G.P. Putnams and Sons, 1958. 45p.

Good motivation and preparation for an actual trip to a planetarium. 65-05-050

ZINER, FEENIE and THOMPSON, ELIZABETH. *The True Book of Time*. Chicago: Childrens Press, 1956. unpagged.

Early time-telling devices and the modern clock in a simple text. 71-12-339

Living Things



ADRIAN, MARY. *Garden Spider*. New York: Holiday House, 1951. 38p. 65-72-001

———. *Gray Squirrel*. New York: Holiday House, 1955. 46p. 65-62-001

———. *Honeybee*. New York: Holiday House, 1952. unpag. 65-72-002

Authentic life histories simply written and attractively illustrated.

ANDREWS, ROY CHAPMAN. *All About Dinosaurs*. New York: Random House, Inc., 1953. 146p.

An eminent scientist tells of the creatures who lived millions of years ago. Describes experience of hunting fossils. 65-42-000

AUDUBON SOCIETY. *Audubon Nature Bulletins*. New York.

Attractively printed and illustrated bulletins, written by authorities in natural history, non-technical, easy-to-read and understand. Includes 60 bulletins under the following categories: animals without backbones, animals, how they live, plant identification, conservation. Good teaching aids. Complete set of 60 bulletins, \$5.00, 15¢ each, 10¢ each for 5 or more copies.

BANCROFT, HENRIETTA and VAN GELDER, RICHARD G. *Animals in Winter*. New York: Thomas Y. Crowell Co., 1963. unpag.

Describes the activities of a number of animals who must survive the rigors of winter. 71-12-008

BLOUGH, GLENN O. *Bird Watchers and Bird Feeders*. New York: McGraw-Hill, 1963. 48p.

Identifying characteristics of various birds, bird banding, and migrations are discussed. Also included are instructions for building a bird feeder. 65-74-002

———. *Discovering Plants*. New York: McGraw-Hill, 1966. 48p.

The author shows reader what to look for and where to look, starting with the roots of plants. Explains functions of each part of plant and shows how each structure is important to the plant.

———. *Look Out for the Forest*. New York: McGraw-Hill, 1955. 48p.

A conservation story, told through a boy's experiences, showing the value of forests and the animals in them and the ways forest farmers and rangers protect our forests against fires. 63-25-002

———. *Soon After September*. New York: McGraw-Hill, 1959. 48p.

Author takes the reader on an imaginary walk where he finds out what happens to plants and animals when winter comes. 65-52-001

———. *Who Lives In This House?* New York: McGraw-Hill, 1957. 48p.

Natural history for younger readers in an easy-to-read narrative about a peek into an old house to see the animals which have "taken it over." 65-62-015

——— and CAMPBELL, MARJORIE H. *When You Go to the Zoo*. New York: McGraw-Hill, 1955. 128p.

For the teacher who wishes to make zoo trips more meaningful. Tells how zoos are set up and how their animals, are obtained, fed, and cared for. 65-62-017

BRIDGES, WILLIAM. *Big Zoo*. New York: Viking Press, 1941. 160p.

Although the book is written for older children, photographs showing what goes on in the Bronx Zoo make it interesting for younger ones too. 65-62-019

BRIDGES, WILLIAM. *Zoo Babies*. New York: William Morrow and Co., 1953. 95p.

True stories about baby animals in the famous zoo at the New York Zoological Park. Fascinating descriptions of the personality of each animal. 65-62-022

- BROWN, VINSON. *How to Make A Miniature Zoo*. Boston: Little, Brown and Co., 1957. 204p.
Suggestions on proper feeding and handling of insects, snakes, fish and rodents at home and in the school.
- BUCK, MARGARET WARING. *Pets from the Pond*. Nashville, Tenn.: Abingdon Press, 1958. 72p.
Exciting experiences for youngsters interested in learning how to find and keep fresh-water pets. 65-73-001
- CASSELL, SYLVIA. *Nature Games and Activities*. New York: Harper, 1956. 87p.
Construction of bird houses, feeders, terraria, displays and collections. Simple games. 65-52-008
- COLLIER, ETHEL. *Who Goes There in My Garden?* New York: Wm. R. Scott, Inc., 1963. unpagged.
A boy buys seeds for a garden. When he plants them, he learns about the balance of nature. Easy reading.
- COMSTOCK, ANNA B. *Handbook of Nature Study*. Ithaca, N.Y.: Comstock Publishing Co., 1947. 942p.
Invaluable to teachers as a source of information and concepts about common plants and animals. For each organism described, there is a "Teacher's Story" and a "Lesson" with a "Leading Thought", "Method", and "Observations". A whole library of natural history in one volume.
- CROSBY, ALEXANDER L. *Junior Science Book of Pond Life*. Champaign, Ill.: Garrard Publishing Co., 1964. 65p.
In conversational style the author explores a pond and its wildlife. Brief descriptions of the habits of frogs, muskrats, snakes, turtles and salamanders. 65-52-001
- DEVOE, ALAN. *This Fascinating Animal World*. New York: McGraw-Hill, 1951. 303p.
Interesting information about many animals from insects to mammals.
- DICKINSON, ALICE. *The First Book of Plants*. New York: Franklin Watts, 1953. 175p.
A simple description of common plants. Illustrated. 65-58-005
- EARLE, OLIVE L. *White Patch, a City Sparrow*. New York: Wm. Morrow and Co., 1958. 64p.
A charming story about a little sparrow who flew on board a ferryboat which took him to Staten Island. Beautiful life-like pictures. 65-74-017
- FRISKEY, MARGARET. *The True Book of Birds We Know*. Chicago: Children's Press, 1954. 47p.
Good introductory book on birds, with illustrations. 65-74-023
- GANS, ROMA. *Birds Eat and Eat and Eat*. New York: Thomas Y. Crowell Co., 1963. unpagged.
Describes how many common birds get their food and where they go to find it. Encourages habits of observation and discovery as children make their own feeders.
- . *It's Nesting Time*. New York: Thomas Y. Crowell Co., 1964. unpagged.
Describes in simple words where and how birds make their nests. Attractive pictures. 71-12-103
- GARELICK, MAY. *What's Inside?* New York: Wm. R. Scott, Inc., 1955. unpagged.
The charming story of a goose egg that hatched. Excellent photographs. 71-01-030

GOLDIN, AUGUSTA. *Ducks Don't Get Wet*. New York: Thomas Y. Crowell, 1965. unpag.

Explains in charming manner why ducks don't get wet. A simple experiment using a feather and salad oil helps children understand why. 71-12-348

———. *Spider Silk*. New York: Thomas Y. Crowell Co., 1964. unpag.

A Let's Read-and-Find-Out science book which tells how spiders hatch, spin silk and catch food. Includes a simple experiment to test the strength of a spider web. 71-12-108

GREEN, MARY MCBURNEY. *Everybody Eats*. New York: Young Scott Books, 1950. unpag.

Very simple book with large print telling what familiar animals eat. Attractively illustrated. 71-12-109

GREENBERG, SYLVIA S. and RASKIN, EDITH L. *Home Made Zoo*. New York: David McKay Co., 1952. 256p.

Helps children (and teachers too) make friends with hamsters, rabbits, mice, guinea pigs, birds, turtles, snakes, salamanders, frogs and tropical fish by showing how to keep them as pets. Gives specific and complete descriptions for handling, feeding, housing and breeding. Suggests materials for building animal homes.

HAWES, JUDY. *Bees and Beelines*. New York: Thomas Y. Crowell, 1964. unpag.

Describes the "training" of bees when they first leave the hive, how they make use of the sun as a guide, their signal system and the dances they use to let other bees know where the flowers are. 71-12-153

———. *Fireflies in the Night*. New York: Thomas Y. Crowell Co., 1963. unpag.

Describes many interesting facts about fireflies: how they are used as lanterns or flashlights; how they provided light for an operation. 71-12-154

———. *Watch Honeybees with Me*. New York: Thomas Y. Crowell Co., 1964. unpag.

Attractive illustrations describe the inside of a beehive, tell how bees live in it and what they do when they fly to gardens and trees. 71-12-155

HESS, LILO. *Easter in November*. New York: Thomas Y. Crowell Co., 1964. 48p.

Nine year old Gail watches her old brown hen care for a boxful of downy baby chicks that grew up into something special: Araucana chickens. 66-50-003

HOGNER, DOROTHY CHILDS. *Frogs and Polliwogs*. New York: Thomas Y. Crowell Co., 1956. 68p.

A detailed account of the life cycle of the frog from egg to maturity. Material also on toads and salamanders. 65-73-012

———. *Earthworms*. New York: Thomas Y. Crowell, 1953. 47p.

Easy reading about the common earthworm; its anatomy, life history and importance. 65-69-016

HUNTINGTON, H.E. *Let's Go to the Brook*. Garden City, N.Y.: Doubleday and Co., Inc., 1952. 90p.

A welcome book for young naturalists ready to explore out-of-doors. Many exceptional pictures taken through water. 65-52-024

- _____. *Let's Go Outdoors*. Garden City: Doubleday and Co., 1939. 89p.
Photographic picture book, with information about small creatures which children frequently see, as snails, earthworms, frogs, toads, turtles, spiders and several kinds of insects. 65-52-023
- HURD, EDITH THACHER. *Starfish*. New York: Thomas Y. Crowell Co., 1962. unpagged.
A charming book in which the young reader finds out about the variety of starfish he might see, the life cycle and habits of these creatures. 71-12-186
- HUSSEY, LOIS J. and PESSINO, CATHERINE. *Collecting Cocoons*. New York: Thomas Y. Crowell Co., 1953. 73p.
In simple words, and with many pictures, the authors introduce the reader to the changes that occur in the life of the egg, caterpillar, pupa and moth. 65-72-027
- HUTCHINS, ROSS E. *Lives of an Oak Tree*. Chicago: Rand McNally and Co., 1962. 64p.
A simple but meaningful picture of the life cycle of an oak tree. 65-59-018
- _____. *The Amazing Seeds*. New York: Dodd, Mead and Co., 1965. 159p.
Lively text reveals strange and interesting facts about seeds and how they insure continuity of plant life. For the teacher.
- JOHNSTON, JOHANNA. *Penguin's Way*. Garden City: Doubleday and Co., 1962. unpagged.
Simple poetic prose describes the year-round life of the emperor penguins and their struggle to survive the rigorous South Pole winters. 65-74-035
- KANE, HENRY B. *Wings, Legs, or Fins*. New York: Alfred A. Knopf, 1965. unpagged.
Exciting photographs and drawings show some of the many different ways that animals can travel.
- KIRKUS, VIRGINIA. *The First Book of Gardening*. New York: Franklin Watts, Inc., 1956. 69p.
Things to know before you start a garden: how to prepare the soil, how to plant seeds, how to care for growing plants. 66-46-002
- LAUBER, PATRICIA. *The Friendly Dolphins*. New York: Random House, Inc., 1963. 81p.
Introducing the bottle-nosed dolphin, its characteristics, intelligence and importance to science. 65-62-091
- MARCHER, MARION. *Monarch Butterfly*. New York: Holiday House, 1954. 46p.
Life cycle of a common butterfly, in story form but scientific in content. 65-72-042
- MCCLUNG, ROBERT M. *Caterpillars and How They Live*. New York: Wm. Morrow and Co., 1965. 63p.
Surveys many kinds of caterpillars and their common characteristics; their habits, defenses against enemies and how they affect man. 65-72-080
- _____. *Tiger: The Story of a Swallowtail Butterfly*. New York: Wm. Morrow and Co., 1953. 48p.
Simple text and pictures which combine scientific accuracy with beauty tell the story of Tiger's first year, from tiny egg to fullgrown butterfly. 65-72-041
- _____. *Honker: The Story of a Wild Goose*. New York: Wm. Morrow & Co., Inc., 1965. 64p.
The story of a year in the life of a Canada goose tells how these majestic birds raise their young and meet the hazards of migration. 65-74-072

- MORGAN, ALFRED. *Aquarium Book for Boys and Girls*. New York: Charles Scribner's Sons, 1936. 175p.
Practical advice on starting an aquarium and taking care of it. 65-73-019
- PARKER, BERTHA M. *The Golden Treasury of Natural History*. New York: Simon and Shuster, Inc., 1952. 216p.
Answers many questions children ask about plants, animals, rocks and the night sky. 65-52-036
- PODENDORF, ILLA. *The True Book of Pets*. Chicago: Children's Press, Inc., 1954. 47p.
How to care for such pets as goldfish, toads, turtles, parakeets, hamsters, rabbits, cats, and dogs. 71-12-266
- ROGERS, MATILDA. *A First Book of Tree Identification*. New York: Random House, 1951. 95p.
Identification is facilitated by large, clear photographs of leaves and bark. Especially useful for young people. 65-59-024
- SCHNEIDER, HERMAN and NINA. *Plants in the City*. New York: The John Day Co., 1951. 96p.
Tells how some plants grow in the city environment. Describes experiments an apartment dweller can do to learn how plants live.
- SCHWARTZ, ELIZABETH and CHARLES. *Cottontail Rabbit*. New York: Holiday House, 1957. 46p.
Life cycle of the familiar rabbit emphasizing its role in nature's food chains. 66-53-001
- SEARS, PAUL M. *Downy Woodpecker*. New York: Holiday House, 1953. 48p.
A downy's life cycle: hunting food, nesting, mating, told in story form. 65-74-053
- SELSAM, MILLICENT E. *Benny's Animals and How He Put Them in Order*. New York: Harper and Row, 1966. 60p.
Benny learns the structure of animals as he tries to classify them. Easy to read.
- . *Nature Detective*. New York: Wm. R. Scott, Inc., 1958. unpagged.
Shows what kind of clues to look for to solve fascinating mystery stories in nature. Includes a bibliography to carry the beginning sleuth on into increasing expertness. 65-62-166
- . *Plants that Move*. New York: Wm. Morrow and Co., 1962. 127p.
Explains with the help of easy-to-do experiments the many ways in which plants grow. 65-58-025
- . *Play with Plants*. New York: Wm. Morrow and Co., 1949. 63p.
A book of enjoyable experiments with plants; producing new plants from parts of plants and from seeds. Pictures help explain the experiments. 65-58-026
- . *Plenty of Fish*. New York: Harper and Row, 1960. 63p.
Tells how a little boy's trip to the five-and-ten to buy goldfish led to greater knowledge of fish and their habits. 71-12-275
- . *See Through the Forest*. New York: Harper and Row, 1956. unpagged.
Explains how the needs of different plants and animals determine the level at which each lives in a forest. Attractively illustrated. 65-52-047

- _____. *A Time for Sleep*. New York: Wm. R. Scott, Inc 1953., unpagged.
A book about the ways that animals sleep or rest. 65-62-167
- _____. *Terry and the Caterpillars*. New York: Harper and Row, 1962. 64p.
Clear and entertaining description of the life cycle of the cecropia moth. 71-12-277
- SHUTTLESWORTH, DOROTHY. *The Story of Ants*. New York: Doubleday 1964. 60p.
Life and living in the insect community. 65-72-076
- STERLING, DOROTHY. *Caterpillars*. New York: Doubleday & Co., Inc., 1961. 64p.
An imaginative introduction to the habits of caterpillars and how to observe and study them. 65-72-056
- VOIGHT, VIRGINIA F. *Picta the Painted Turtle*. New York: G. P. Putnam Sons, 1963. 63p.
Describes the activities and adventures of a pretty turtle in a pond inhabited by different kinds of animals.
- WEBBER, IRMA. *Bits that Grow Big: Where Plants Come From*. New York: Wm. R. Scott, Inc. 1949. 64p.
How to grow plants from seeds, spores, bulbs, cuttings. Stresses experimental viewpoint. Uses simple, everyday materials. 65-58-032
- _____. *Thanks to Trees: The Story of Their Use and Conservation*. New York: Wm. R. Scott, Inc., 1962. 64p.
- Attractive first book on the value of trees to man and the need for protecting them. 63-25-035
- _____. *Travellers All: How Plants Go Places*. New York: Wm. R. Scott, Inc., 1944. unpagged.
Attractively illustrated first book of how seeds travel by land, water, air and with the aid (unwitting) of animals. 65-58-033
- WILLIAMSON, MARGARET. *The First Book of Mammals*. New York: Franklin Watts, Inc., 1957. 62p.
Forty-five mammals from all over the world briefly described and beautifully illustrated. How the young kangaroo is born, how the odd platypus nurses its young, and others. 65-62-188
- WISE, WILLIAM. *In the Time of the Dinosaurs*. New York: G. P. Putnam's Sons, 1963. 64p.
Tells what the world was like when different kinds of dinosaurs roamed around.
- _____. *The World of Giant Mammals*. New York: G. P. Putnam's Sons, 1965. 64p.
Explores the less known but fascinating world of the giant mammals which followed the great lizards. 65-42-036
- ZIM, HERBERT S. *Golden Hamsters*. New York: Wm. Morrow and Co., 1951. 63p.
Tells how to care for these little animals; how to build cages for them, how to handle and feed them; how to breed them. 66-53-033
- _____. *Goldfish*. New York: Wm. Morrow and Co., 1947. 64p.
Brief history of goldfish; how they live; how to set up an aquarium. 65-73-027

Sound and Light



- BAER, MARIAN.** *Sound: An Experiment Book.* New York: Holiday House. 1952. 127p.
Elementary experiments that lead to an understanding of the principles of sound. 65-16-001
- BARR, GEORGE.** *More Research for Young Scientists.* New York: McGraw-Hill, 1961. 159p.
More than 80 uncomplicated open-ended experiments, many of which are appropriate for this age group.
- BRANLEY, FRANKLYN M. and VAUGHAN, ELEANOR K.** *Timmy and the Tin-can Telephone.* New York: Thomas Y. Crowell, 1959. 36p.
Making of a telephone. Simple narrative written in a lively story fashion. Easy to read. 65-16-003
- FREEMAN, IRA M.** *All About Sound and Ultrasonics.* New York: Random House, 1961.
Tells what scientists have discovered about sound. Explains some of the research being done in this area. Fine book for teacher and interested pupil. 65-16-005
- GERALTON, JAMES.** *The Story of Sound.* New York: Harcourt, Brace and Co., 1948. unpagged.
Noises, vibrations, how sounds travel, how we hear sounds. 65-16-006
- IRVING, ROBERT.** *Sound and Ultrasonics.* New York: Alfred A. Knopf, 1959. 146p.
Explores the nature of sounds, including those which the ear cannot detect. Has material on the recording of sound and how various animals, including man, hear. 65-16-007
- KETTLEKAMP, LARRY.** *The Magic of Sound.* New York: Wm. Morrow and Co., 1956. 63p.
Discusses the principles and uses of sound with the help of simple experiments. 65-16-008
- KOHN, BERNICE.** *Echoes.* New York: Coward-McCann Inc., 1965. unpagged.
Presents basic concepts about echoes. Explains how echoes cause problems, how these problems can be solved. How bats and undersea animals use echoes.
- MEYER, JEROME S.** *Sound and Its Reproduction.* New York: The World Publishing Co., 1964. 64p.
Description of the basic principles of sound. Methods of recording and reproducing sound are explained; the uses of ultrasonic sound. 65-16-010
- PINE, TILLIE S. and LEVINE, JOSEPH.** *Sounds All Around Us.* New York: McGraw-Hill, 1952. 96p.
Simple experiments and experiences with sound; stresses basic principles. 65-16-011
- ROWLAND, KURT.** *The Telephone.* New York: The John Day Company, 1962. 48p.
The story of the development of the telephone and how the telephone works.
- RUSSELL, SOLVEIG PAULSON.** *Sound.* Indiana: The Bobbs-Merrill Co. Inc., 196? unpagged.
A simple discussion of the principles of sound. Well illustrated.

SCHNEIDER, HERMAN and NINA. *Your Telephone and How It Works*. New York: McGraw-Hill, 1965.

Explanation of the principles on which the telephone works. Included are the latest advances in this method of communication. 66-17-007

WINDLE, ERIC. *Sounds You Cannot Hear*. Englewood Cliffs, N. J.: Prentice-Hall Inc., 1963. 69p.

Explains the principles of ultrasonics. Discusses the present and possible future uses of "silent sound." 65-16-014

Weather



ADELSON, LEONE. *All Ready for Winter*. New York: McKay, 1962. unpagcd.

In simple, poetic language and with pictures children learn what happens to children and animals when winter comes. 71-00-007

ADLER, IRVING. *Weather in Your Life*. New York: The John Day Company, 1959. 126p.

Explores ways of studying, forecasting and changing the weather. For interested children and teachers. 65-36-001

ANTOINE, TEX. *Wonders of the Weather*. New York: Dodd, Mead and Co., 1962. 64p.

The well-known weather commentator explains the weather. Illustrated by the author. 65-36-004

BELL, THELMA. *Snow*. New York: Viking Press, 1954, 56p.

The way snowflakes are formed; types of snowflakes; how snow can be helpful as well as harmful to man. Also tells about frost, rime, glaze, sleet and hail. 65-36-005

BENDICK, JEANNE. *All Around You*. New York: McGraw-Hill, 1951. 48p.

A picture book which presents a first look at the sun, moon, clouds, water, soil, seeds, plants, animals and other natural phenomena. 65-00-008

———. *Lightning*. New York: Rand McNally, 1961. 61p.

Simple explanation of lightning. 65-36-006

———. *The Wind*. New York: Rand McNally, 1964. 80p.

From fascinating myths and superstitions of wind to how wind affects everything around us. Delightful illustrations and humor. 65-36-007

BLACK, IRMA SIMONTON. *Busy Water*. New York: Holiday House, 1958. unpagcd.

The ways and work of busy water and the water cycle are simply explained in rollicking kind of prose. 71-00-136

BLOUGH, GLENN O. *Not Only For Ducks*. New York: McGraw-Hill, 1954. 48p.

A boy learns how rain is essential for all living things. A simple story of the weather cycle. 65-36-009

———. *Wait for the Sunshine*. New York: McGraw-Hill, 1954. 48p.

The seasons and growing things explained through the experiences of a boy who investigates the food-making activities of plants. 65-58-001

BRANLEY, FRANKLYN M. *Flash, Crash, Rumble, and Roll*. New York: Thomas Y. Crowell Co., 1964. unpag.

How an electrical charge builds up in a thundercloud until it produces a lightning flash and thunder. Reassuring instructions for safety during a storm.

_____. *Rain and Hail*. New York: Thomas Y. Crowell Co., 1963. unpag.

Gives an explicit, simple explanation of what makes rain and hail. Bold drawings and easy-to-read text. 71-12-053

_____. *Snow Is Falling*. New York: Thomas Y. Crowell Co., 1963. unpag.

Simple text answers the questions about snow and snowflakes that children ask. Children are encouraged to find out for themselves 71-12-055

FORRESTER, FRANK H. *1001 Questions Answered About the Weather*. New York: Dodd, Mead and Co., 1957. 419p.

Teachers and students will find this book an excellent source of useful information about weather.

GALLANT, ROY A. *Exploring the Weather*. Garden City: Garden City Books, 1957. 64p.

Explores the weather, explaining what it is and how it is made. Describes hurricanes, tornadoes, and thunderstorms. Very good illustrations. 65-36-016

HITTE, KATHRYN. *Hurricanes, Tornadoes and Blizzards*. New York: Random House, 1960. 82p.

How scientists look for causes of great storms. An Easy-to-Read Book. 65-36-019

IRVING, ROBERT. *Hurricanes and Twisters*. New York: Alfred A. Knopf, 1957. 144p.

A treasury of fascinating information about unusual storms authenticated by expert meteorologists. 65-36-020

MILGROM, HARRY and RUCHLIS, HY. *Science Book of Air Experiments*. New York: Science Material's Center, 1961.

Experiments with simple materials develop fundamental concepts about weather. 65-15-002

NEURATH, MARIE. *The Wonder World of Snow and Ice*. New York: Lothrop, Lee and Shepard Co., Inc. 1963. 36p.

Explains how animals that inhabit regions of ice and snow manage to survive extreme cold. Vividly illustrated. 65-52-035

PARTRIDGE, J. A. *Natural Science Through The Seasons*. New York: Macmillan, 1954.

The teacher will get many ideas for nature activities from this excellent source book.

PINE, TILLIE S. and LEVINE, JOSEPH. *Water All Around*. New York: McGraw-Hill, 1959. 48p.

Tells many things about water: where it is found; how it condenses out of the air; how it helps to make weather. 65-15-003

SCHNEIDER, HERMAN. *Everyday Weather and How It Works*. New York: McGraw-Hill, 1961. 194p.

Helps reader understand easily what weather really is; gives data on new weather-detection devices; explains how to use weather maps; gives instructions for making a home weather-forecasting station. 65-36-033

SCHNEIDER, HERMAN. *Everyday Weather and How It Works*. New York: McGraw-Hill, 1961. 194p.

Properties of heat, water and air are studied. Children find answers to questions by performing simple experiments with everyday materials. 65-13-012

SPAR, JEROME. *The Way of the Weather*. Mankato, Minn.: Creative Educational Society, 1957. 224p.

Full page photographs with facing text convey the feeling as well as the science of weather. 65-36-034

SPIILHAUS, ATHELSTAN F. *Weathercraft*. New York: Viking Press, 1951. 64p.

Tells how to assemble and operate weather instruments using materials around the house. Helps children make weather predictions on their own. 65-36-035

TRESSELT, ALVIN. *White Snow, Bright Snow*. New York: Lothrop, Lee and Shepard Co., 1959. 33p.

Describes the practical things grownups do when a snowstorm comes. Captures the wonder and delight a child feels as the snow falls. Easy-to-read. 71-02-355

WYLER, ROSE. *The First Book of Weather*. New York: Franklin Watts, Inc., 1956. 63p.

Explains what makes weather; simple experiments and directions for making weather instruments and reading weather maps are included. 65-36-042

ZIM, H. S. *Lightning and Thunder*. New York: Wm. Morrow and Co., 1952. unpagged.

Kinds of lightning, its effects, locating it, lightning rods. 65-36-043

Force and Motion in Transportation



BECHDOLT, JACK. *Going Up: The Story of Vertical Transportation*. New York: Abingdon-Cokesbury Press, 1948. 128p.

Tells the story of how man invented the lever, the wheel and the pulley to help him. 66-16-001

MILGROM, HARRY. *Adventures with a Ball*. New York: E. P. Dutton & Co., Inc. 1965. 31p.

Experimenting with a ball, a child becomes imbued with the spirit of exploration and discovery in science. 71-12-371

———. *Adventures With a String*. New York: E. P. Dutton & Co., Inc., 1965. 32p.

Helps a child find out many things for himself by experimenting with a piece of string. Develops a spirit of exploration and discovery. 71-12-372

PINE, TILLIE S. and LEVINE, JOSEPH. *Friction All Around*. New York: McGraw-Hill, 1960. 46p.

Explains friction by examining everyday situations in which it occurs. 65-14-004

———. *Gravity All Around*. New York: McGraw-Hill, 1963. 48p.

Explains gravity on earth and in outer space. Experiments included. 65-14-005

———. *Simple Machines and How We Use Them*. New York: McGraw-Hill, 1965. 48p.

How simple machines can make it easier to lift, turn and cut things; demonstrated with the help of many experiments. 66-16-030

SCHNEIDER, HERMAN. *Everyday Machines and How They Work*. New York: McGraw-Hill, 1950. 192p.

Shows how levers, wheels, inclined planes and pulleys are used in familiar things like window shades, egg-beaters and meat grinders. 66-61-002

- and NINA. *Now Try This to Move a Heavy Load*. New York: Wm. R. Scott, Inc., 40p.
Use of friction, wheels, leevrs and inclined planes in transportation. 65-13-010
- SHARP, ELIZABETH N. *Simple Machines and How They Work*. New York: Random House, 1959. 83p.
Explains how the wheel, the pulley, the screw and other simple machines help us. Simple experiments are included. 66-16-022
- WYLER, ROSE, AMES, GERALD. *What Makes It Go?* New York: McGraw-Hill, 1958.
Explains the part played by friction; ball bearings; sources of energy in machines. 66-16-024

Earth and its Resources



- BARR, GEORGE. *Young Scientist Takes a Walk*. New York: McGraw-Hill, 1959. 160p.
A guide to outdoor observations in which children use their own environment to answer science questions. 65-52-000
- BARTLETT, MARGARET FARRINGTON. *Down the Mountain*. New York: Young Scott Books, 1963. 63p.
During a walk down the side of a mountain, the reader learns about how soil is carried away and built up.
- BAUER, HELEN. *Water: Riches or Ruin*. New York: Doubleday, 1959. 121p.
Relationship of water, erosion, floods, wiser use of water and soil. 63-25-001
- BENDICK, JEANNE. *What Could You See?* New York: Whittlesey House, McGraw-Hill Book Co., 1957. 32p.
Discoveries children can make in their own environment about soil, rocks, minerals, and forests. 65-00-009
- BLACK, IRMA SIMONTON. *Busy Water*. New York: Holiday House, 1958. unpagged.
The water cycle is described in lively prose. 71-00-136
- BLOUGH, GLENN O. *Not Only for Ducks*. New York: McGraw-Hill, 1954. 46p.
Reader learns about the importance of rain for living things. 65-36-009
- CORMACK, MARIBELLE. *The First Book of Stones*. New York: Franklin Watts, 1950. 93p.
Tells how to collect, identify, and classify rocks. 65-38-006
- CROSBY, ALEXANDER L. *Junior Science Book of Pond Life*. Champaign, Ill.: Garrard Publishing Co., 1964. 64p.
In conversational style the author lets us explore his pond and its wildlife. The habits of frogs, herons, muskrats, snakes, turtles, salamanders. 65-52-011
- GANS, ROMA. *The Wonder of Stones*. New York: Thomas Y. Crowell Company, 1963. unpagged.
A simple account of the history of rocks. 71-12-106
- GOLDIN, AUGUSTA. *Salt*. New York: Thomas Y. Crowell Co., 1965. unpagged.
An easy-to-read description of the importance, characteristics, and origins of salt.

IRVING, ROBERT. *Rocks and Minerals and the Story They Tell*. New York: Alfred A. Knopf, 1956. 175p.

Tells how rocks and minerals are formed, where they can be found and how to collect them. 65-38-014

LIFE MAGAZINE. *The World We Live In*. New York: Simon and Shuster, 1956. 216p.

A beautifully illustrated book about the earth, the forces which change it and the living things which live on its surface and in its waters.

NAMOWITZ, SAMUEL N. and STONE, DONALD B. *Earth Science: The World We Live In*. New York: D. Van Nostrand Co., 1965.

This high school textbook has excellent chapters on weather and climate; a useful reference for the teacher. 477-591.1

ORR, CATHERINE E. and DEVAULT, VEREM. *Geology*. Austin, Texas: The Steck Company, 1959. 47p.

Simple, informative. Each idea is enriched by a first-hand experience.

PEARL, RICHARD M. *1001 Questions Answered About the Mineral Kingdom*. New York: Dood, Mead and Co., 1959. 326p.

A storehouse of information; useful for pupils and teachers.

PINE, TILLIE S. and LEVINE, JOSEPH. *Air All Around*. New York: McGraw-Hill, 1960. 48p.

Deals with the nature of air; has some simple experiments. 65-36-031

———. *Water All Around*. New York: McGraw-Hill, 1959. 48p.

Experiments and experiences with water, as it affects young people. 65-15-003

———. *The Egyptians Knew*. New York: McGraw-Hill, 1964. 30p.

Shows how the Egyptians overcame friction and used the inclined plane and lever to make their work easier. 65-00-058

———. *The Eskimos Knew*. New York: McGraw-Hill, 1962. 32p.

Shows how the Eskimos solved problems of everyday living. Explains how the same principles apply now. 65-00059

PINE, TILLIE S. *The Indians Knew*. New York: McGraw-Hill, 1957. 32p.

Tells about the many things the Indians knew how to do long ago and how we use the same principles today. 65-00-056

——— and LEVINE, JOSEPH. *The Pilgrims Knew*. New York: McGraw-Hill, 1957. 32p.

Pictures life in Plymouth colony and shows how science principles helped the Pilgrims in the same way it helps us today. 65-00-060

RUCHLIS, HY. *Your Changing Earth*. New York: Harvey House, Inc., 1963. 40p.

Tells about the history of the earth; the great changes it has undergone and the changes which still go on. 65-29-020

SCHNEIDER, HERMAN and NINA. *Let's Look Inside Your House*. New York: William R. Scott, Inc., 1948. 39p.

A series of safe easy-to-do experiments help children understand the things that seem like magic in the home. Shows how science makes daily living easier. 65-13-008

———. *Let's Look Under the City*. New York: Wm. R. Scott, 1954. 72p.

Public utilities; water, gas, sewage disposal, telephone electricity. 66-28-008

- _____. *Rocks, Rivers and the Changing Earth*. New York: Wm. R. Scott, Inc., 1952. 181p.
Tells about the changing earth and the forces responsible for these changes. Experiments that help explain the formation of various bodies of water; the building and erosion of soil and rock; mineral resources. 65-29-021
- SCHWARTZ, JULIUS. *It's Fun to Know Why: Experiments with Things Around Us*. New York: McGraw-Hill, 1952. 125p.
How man obtains and uses iron, coal, cement, glass, rubber, wood, salt, bread, soap and paper. Ideas reinforced by simple experiments with everyday materials. 65-00-067
- _____. *Through the Magnifying Glass*. McGraw-Hill, 1954. 142p.
Exploring crystals, atoms and other wonders with the aid of a magnifying glass. 65-00-069
- SELSAM, MILLICENT E. *Birth of an Island*. New York: Harper and Brothers, 1959. 48p.
The birth of a volcanic island and the way in which plants and animals come to it. 65-35-044
- _____. *See Along the Shore*. New York: Harper and Brothers, 1961. unpagged.
The author leads her readers on an exciting journey of discovery at the seashore, with its unique forms of life.
- SHANNON, TERRY. *About the Land, the Rain and Us*. Chicago, Ill.: Melmont Publishers, Inc., 1963. 31p.
Tells about the importance of soil and water and what we must do to conserve them. 63-25-030
- _____. *Among the Rocks*. New York: Sterling Publishing Co., Inc., 1958. unpagged.
Book gives a great deal of information about rocks; how they are formed; what sand is; how crystals and slate came to be; what fossils are.
- SONNEBORN, RUTH. *The Question and Answer Book of Everyday Science*. New York: Random House, 1961. 69p.
Clear simple answers to the many questions children ask about themselves, the objects they use, and the world around them. 65-00-070
- TANGBORN, WENDELL V. *Glaciers*. New York: Thomas Y. Crowell Co., 1965. unpagged.
Tells in simple language what glaciers are, how they are formed and why they move. Tells how to look for traces left by glaciers. 71-12-377
- URELL, CATHERINE and NONNENMACHER, ROSAMUNDA. *Big City Water Supply*. Chicago, Ill.: Follett Publishing Co., 1952. 96p.
The story of New York City's Water Supply. 63-25-032
- WHITE, ANNE TERRY. *All About Our Changing Rocks*. New York: Random House, 1955. 142p.
Tells of the great changes that have produced different rocks and explains how to identify rocks. 65-38-030
- _____. *All About Great Rivers of the World*. New York: Random House, 1957. 150p.
The development and changes in rivers is explored. 63-35-049
- _____. *Rocks All Around Us*. New York: Random House, 1950. 82p.
An easy-to-read book about the history of common rocks. 65-38-031

PROFESSIONAL BOOKS ON THE TEACHING OF SCIENCE IN THE ELEMENTARY SCHOOLS

BLOUGH, GLENN O. and SCHWARTZ, JULIUS. *Elementary School Science and How to Teach It*. New York: Holt Rinehart and Winston, 1964.

Combines a survey of science subject content with methods of teaching in the elementary school.

CRAIG, GERALD S. *Science for the Elementary School Teacher*. Boston: Ginn and Co., 1958.

Provides the teacher with a background in science and with methods of teaching it.

HENNESSY, DAVID E. *Elementary Teacher's Classroom Science Demonstrations and Activities*. Englewood Cliffs, New Jersey: Prentice-Hall, 1964.

Materials and procedures in elementary science.

HONE, ELIZABETH B. and others. *A Sourcebook for Elementary Science*. New York: Harcourt, Brace and Company, 1962.

Techniques and procedures for teaching science.

HUBLER, CLARK. *Working With Children in Science*. Boston: Houghton Mifflin, 1957.

General treatment of problems of teaching science in the elementary school.

LEWIS, JUNE E. and POTTER, IRENE. *The Teaching of Science in the Elementary School*. Englewood Cliffs, New Jersey: Prentice-Hall, 1961.

Teaching suggestions and subject matter.

NAVARRA, JOHN G. and ZAFFARONI, JOSEPH. *Science Today for the Elementary School Teacher*. New York: Harper and Row, 1960.

Teaching suggestions and subject matter.

TANNENBAUM, HAROLD E.; STILLMAN, NATHAN; and PILTZ, ALBERT. *Science Education for Elementary School Teachers*. Boston: Allyn and Bacon, 1965.

Goals, methods, child development in relation to elementary school science.

VICTOR, EDWARD. *Science for the Elementary School*. New York: Macmillan, 1965.

Teaching methods and outlines of content.